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IMPROVED BALANCING MACHINE.

THIS engraving represents the Seymour patent centrifugal balancing machine, designed for the purpose of perfectly balancing pulleys, fly wheels, car wheels, and other rotating parts of machinery.

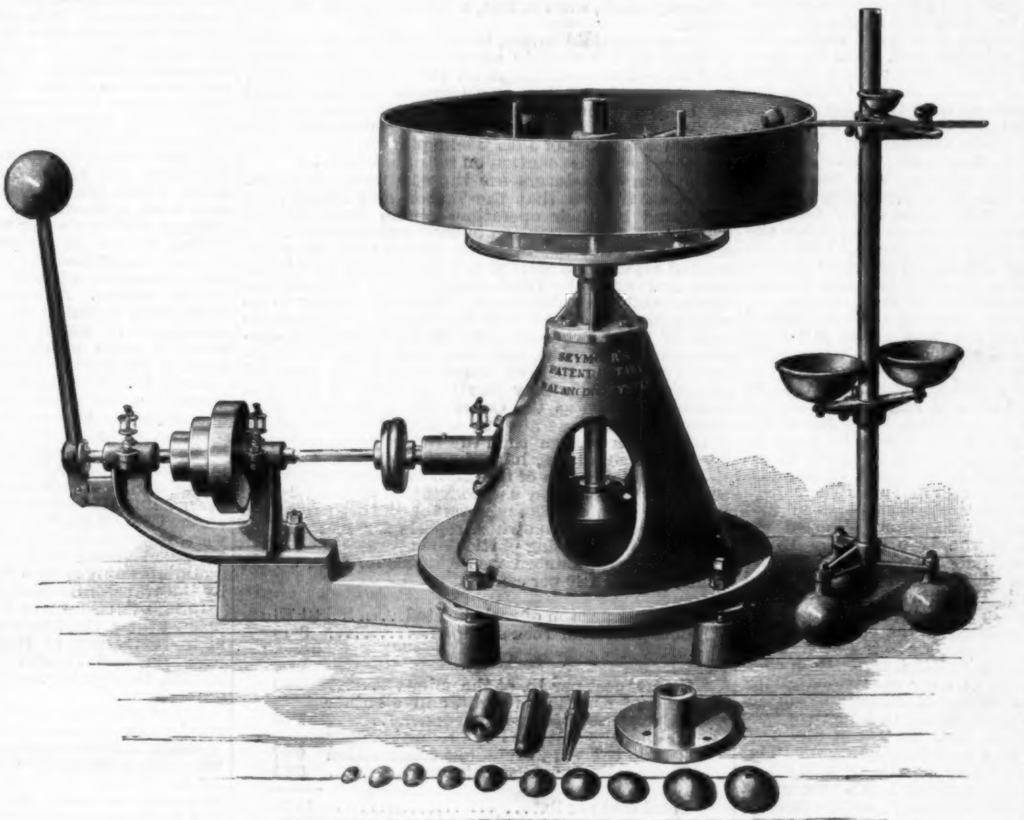
The frame is conical in form and cast in one piece, in the center of which is placed a vertical steel spindle standing in a step bearing in the base of the frame and passing a short distance above through a bearing at the top of the frame. This spindle at its upper end carries a face plate provided with two driving pins which project upward parallel to the axis of the spindle. A steel center with taper shank is fitted into the vertical spindle; its upper end is reduced to a conical point, and upon this rests the object to be balanced.

The vertical spindle is rotated by frictional gearing driven by a horizontal shaft in suitable bearings at the base of the machine. This horizontal shaft is in two pieces, and connected by a friction clutch and moved longitudinally by a counter-weighted lever, so arranged that the weight may be used to press the clutches together when it is desired to rotate the object to be balanced and to disconnect the clutches when it is desired to examine, test and mark the object while running alone, as the driving pins are liable, when pressing against the arms of the object to be balanced, to produce uneven rotation. The true unbalanced condition is best shown when the disturbing influences of the motive power are withdrawn, when the clutch is released.

To balance any object, a plug is first secured having a conical cavity at one end, which is secured to the bored hole of the hub, slightly above the center of gravity of the object to be balanced, then secure a standing balance, first, before starting the machine, by attaching balancing weights by the usual method, then rotate the object, observing and marking the part which runs out, and by adjusting the weights in a vertical plane only, the running balance is secured without destroying the standing balance.

This machine is well adapted for determining all the conditions necessary to perfect rotating balances even at the highest velocity, and by the aid of this machine more objects can be balanced in a given time than by the old method. Weight of machine complete, 1,350 pounds; total floor space occupied, 5 ft. by 3 ft.; tight and loose pulleys, 7 in. by 2½ in.; speed, 725 rotations per minute. Each machine is furnished with one large and one small center, one plug, one large and one small face plate, ten different sized balancing weights as patterns, and one tripod complete, as shown by the engraving.

Further information may be had by addressing the Defiance Machine Works, Defiance, Ohio.



SEYMOUR'S ROTARY BALANCING MACHINE.

THE COPPER RESOURCES OF THE UNITED STATES.

By JAMES DOUGLAS.*

THE growth of the copper production of the United States affords an apt illustration of the speed with which industrial enterprises develop under the combined influences of great natural resources, of modern machinery used with intelligence and skill, and of a system of liberal land and mining laws, which stimulate to the utmost individual initiative and industry. But, of course, the first condition necessary is the existence of the raw material, in the form of copper ore; and this the United States possesses in quantity which has enabled it to rise rapidly to the position of not only the largest producer, but of the largest exporter, among the mining communities of the world.

To describe briefly the locality of the several groups of its large copper mines, the character of the ore, and the local conditions which influence production, is my task.

Each of the main geographical subdivisions of the United States possesses a distinct group of copper deposits.

The Appalachian chain of mountains, which skirts the Atlantic coast, carries throughout its entire extent, from far beyond the northern limits of the United States to near the Gulf of Mexico, copper, which is chiefly, but not exclusively, contained in masses of iron pyrites embedded in crystalline slates. Copper mines were worked before the revolution in Connecticut, New Jersey, and Pennsylvania; and the crude ore, of necessity, in obedience to the laws of trade, exported to this country. More recently mines have been worked in nearly all the Eastern, Middle, and Southern States from Maine to Alabama, but most extensively in Vermont and Tennessee. Vermont in 1880 produced from the Ely Mine over 3,000,000 lb. of metallic copper, but since that date till recently that State has not appeared as a large contributor in the annual statistics.

Tennessee, from the Ducktown Mines, was, from 1846 till the breaking out of the war of secession, the largest producer on the continent, but her mines have been closed for many years. In the States adjacent to Tennessee, in Virginia and North Carolina, Georgia, and Alabama, there exist large deposits of iron pyrites, but in the largest copper-bearing mines the pyrites exists as pyrrhotite, and is, therefore, not in favor with the acid makers, while the copper is not of high grade. The statistics of 1891 assign only 1,300,000 lb. of copper to the Eastern and Southern States. It is probable that they will, in the future, acquire a more prominent position, though, so far as we know, they contain no masses of ore of size and richness sufficient to make their production really important.

From the great trough between the Appalachian and Rocky Mountain chains, drained by the great lakes and the Mississippi, but little copper has been extracted except from the State of Michigan. A sulphureted ore has been worked at Genevieve, Missouri, on the Mississippi River. Copper exists in Arkansas; and through Northwestern Texas run beds of sandstone, probably of Permian age, impregnated more or less with copper glance, but which have not as yet been profitably worked. Within this zone, therefore, of the United States our attention may be confined to what are known as the copper-bearing beds of the Keweenaw series. These consist of beds of trap sandstone and conglomerate of doubtful age.* They rise at a steep angle of about 45° out of the horizontal sandstone from which the basin of Lake Superior has been in great measure eroded.

They have but a limited development on the north shore of Lake Superior, where they are being explored for copper in Michipocotan Island. They form the island of Isle Royale, where much mining has been done and little profit made; and they constitute the backbone of the Keweenaw promontory, which protrudes far into Lake Superior from the south shore. Beyond Michigan the same series of rocks stretches through Wisconsin into Minnesota, but in Michigan alone have they yielded copper in profitable quantities, though elsewhere throughout their whole extent copper is found as one of their associated minerals. Everywhere in Michigan the copper of the Keweenaw series exists exclusively in the metallic state, but in Minnesota I have seen sulphurets with native copper in conglomerate.

Three classes of deposits have been worked on the Keweenaw promontory. *First*, veins which in some instances cut, and in others are parallel with the beds, but which are filled by vein stone different from the intersected rocks. It is these veins which yielded those extraordinary masses, stray blocks of which were reverenced by the Indians, which attracted the attention of the Jesuit Fathers, and which have since appealed so vividly to the popular fancy. *Secondly*, copper-bearing beds of amygdaloidal diabase, locally called *ash beds* and amygdaloidal traps. *Thirdly*, beds of conglomerate of which the cementing material consists in part of copper.

The first announcement to Europe of the existence of native copper on Lake Superior was made by the Jesuit

* From the *Journal of the Society of Arts*, London.

The chairman, Sir Isaac Lowthian Bell, Bart., F.R.S., in introducing Mr. Douglas, said that he had the pleasure of making his acquaintance nearly twenty years ago when visiting the United States. At that time Mr. Douglas was engaged in carrying out a very ingenious and elaborate mode of obtaining copper, the invention of his late friend, Dr. Sterry Hunt. That was conducted by Mr. Douglas for some years with considerable success, but a change in the value of the materials employed, and other circumstances, rendered it impossible to continue that comparatively simple process. Since that time Mr. Douglas had been engaged in very extensive copper enterprises, and he had at present under his direction establishments representing the second largest company in the United States; and he need not remind the members of the society that the United States stood in the first rank as a producer, not only of the metal with which he (the chairman) was more particularly connected, but also of copper.

* The following letter by the late Dr. T. Sterry Hunt, written in 1874, is interesting in this connection:

"DEAR DOUGLAS: Having read with pleasure your article in the *Quarterly Journal of Science*, on 'The Native Copper Mines of Lake Superior,' I venture to offer you some remarks on their geological relations, founded chiefly on my studies in that region in 1872. There has been much difference of opinion as to the age of the great copper-bearing formations of Lake Superior. At an early day it was, on lithological grounds, regarded as mesozoic, but recent observations clearly show that the cupriferous series of the Keweenaw Peninsula, consisting of sandstones, conglomerates, and trappean rocks, is unconformably overlaid by horizontal sandstones which support, in their turn, limestones holding the organic remains of the Trenton Group (Upper Cambrian). According to Brookes and Pumpelly, no difference in altitude is perceived between this copper-bearing series, which may be distinguished as the Keweenaw Group, and the crystalline schists of the Huronians which underlie it. It is, however, to be noted that the red feldspar porphyry, the pebbles of which make up the conglomerate bed of the Calumet and Hecla Mine, is apparently identical with the porphyry which, along our Eastern shores, appears to constitute a member of the Huronian series. There was, I conceive, a wide interval of time between the Huronians and the Keweenaw Group; and the copper of the latter was probably derived from the solutions formed by oxidation of the cupriferous sulphurets, which everywhere abound in the Huronian. The horizontal sandstones of the Keweenaw Peninsula and those of Sault Ste. Marie are doubtless identical. It is in the vicinity of Thunder Bay, on the northern shore of the lake, that are seen the strata which Sir W. Logan made the types of his *upper copper-bearing series*. What he called the *upper division* of his series consists of red and white sandstones, with marls and limestones, which rest, as may be seen, near Silver Islet, in slight unconformity upon the *lower division*, made up of dark grayish or blackish argillites and sandstones. These in Thunder Bay rest directly upon the crystalline schists of the Huronians, and are traversed both by diorite dikes and a series of silver-bearing lodes posterior to the dikes, and extending into the Huronians. This *lower division*, which is not known further eastward, nor in the Keweenaw Peninsula, I have elsewhere called the *Animikie Group*, from the Indian name of Thunder Bay, while the red sandstones and marls I have called the *Nipigon Group* (a term originally proposed by Professor Bell, to include both this and the Animitric Group). These two groups, which constitute together the typical upper copper-bearing series of Logan, are, by Macfarlane and Bell, considered to be mesozoic, and the question arises as to their relation to the two series of uncrystalline rocks of the Keweenaw region. Are the red sandstones of the Nipigon Group the equivalents of the horizontal sandstones of the Portage Lake and Sault Ste. Marie? or do they correspond to the more ancient sandstones, which are interstratified with the copper-bearing Keweenaw Group? I have elsewhere expressed the opinion that they are probably distinct from and newer than either of these. Faithfully yours, T. STERRY HUNT.

"Boston, August, 1874."

Fathers in 1659. Pere Alouez described in 1666 a stray mass on Ontonagon River; but long prior to that date the Indians had mined the native copper, and fashioned it into ornaments and weapons. After the conquest of Canada, and prior to the revolutionary war, Alexander Henry organized a company in this country, with the Duke of Gloucester, Charles Townshend, and other men of note as incorporators, to extract and export the native copper ores of Lake Superior.

After two years of unsuccessful existence, the company was extinguished by the sale for its debts of the first cargo of native copper ore which reached this country. It has always seemed to me that Mr. Townshend's unfortunate private venture may have embittered his feelings toward North America, and been an indirect incentive to his unpopular financial policy, which precipitated the revolutionary war. Michigan did not pass into the possession of the United States till 1796, and nearly half a century more elapsed before it became a self-governing State, and the Indians' titles to the land were extinguished. Then mining commenced in earnest. The first mines which were extensively and successfully worked were the Cliff and Minnesota. These and a host of less important were opened on the transverse veins of Keweenaw County, near the point of the promontory, and on the bedded veins of Ontonagon County, and attracted investments in some instances by the profits they yielded, and in all by the hope of finding such masses of native copper as were frequently found in the upper levels of the Cliff and Minnesota. The only mass mine working to-day is the Central, and from its lower levels no large masses have been extracted, for as was the case in all the veins without exception, the masses grew fewer and the vein poorer as depth was attained. The distribution of the masses through the veins was everywhere so irregular that no rule of search could be followed.

The largest mass found in the Minnesota Mine was about 500 tons in weight, but from the Central Mine was extracted one of 600 tons, to which were attached, by distinct metallic feeders, minor masses of about the same aggregate weight, thus making the total weight of this mass and its branches 1,200 tons. These huge masses, which filled the vein and protruded sometimes into the walls, were cut by chisels into blocks of about 10 tons before being hoisted, and were smelted in special refineries with a movable roof. But though a large mass, when found, would often prove a treasure trove, the occurrence of masses in the Central, for instance, has always been so rare that the average yield of all the ore treated has only been 1·9 per cent. of copper, and of this about one-half has been recovered, as what is called stamp work or concentrates, and one-half only from the masses. The veins have varied from 30 ft. in width to a mere seam, and the productive chutes of ore were never many hundred feet in length. In the Central, for instance, below the 900 foot level the pay chute has not averaged 300 ft. in length. A mass mine has consequently never been a large producer, and at present all these once famous mines together do not yield 2,000,000 lb. of copper.

The second group of mines, namely, those on beds of amygdaloidal trap, succeed the mass mines in date of development and in rate of production. In the early days of lake mining it is easy to conceive of the fascination that the mass mines exercised, and that an ore containing a few small and scattered grains of copper was looked upon as worthless. But one of the old companies, the Copper Falls, failing to work its vein profitably, was tempted, in 1851, to make an experiment on rock extracted from a bed of amygdaloidal trap, across which the vein had cut. The experiment proved so far satisfactory that between that date and 1865 a number of companies attacked the copper-bearing portion of the trap beds; of which companies most have succumbed, but several, notably the Quincy, which has absorbed the Franklin and Pewabic, and the South Pewabic, now the Atlantic, have continued to maintain a vigorous existence. The Quincy is situated immediately to the east of Portage Lake, and the Atlantic immediately to the west. They are on different beds of amygdaloidal trap. Both companies publish full reports of their operations, giving interesting particulars of the cost of mining and concentrating. The Quincy Mine is opened to a depth of 4,000 ft., on the inclination of the bed. In 1891 it produced 10,542,019 lb. of copper, at a cost for mining, smelting, and transporting, and ordinary repairs, of \$652,410 or 6·19 cents, but \$311,859 were expended on a new mill, a railroad, and other extraordinary improvements, which, added to the cost of copper, brought it up to 9·14 cts. per pound of ingot in New York.

These extraordinary improvement costs will not continue to be incurred in future years. Prior to the era of expansion of plant—that is, say between 1885 and 1888—the cost of mining copper, all expenses included, was about 7½ cents per lb., and that cost will probably be slightly reduced by the improvements just completed. This result is obtained from the treatment of an ore which has yielded on an average, after rough hand sorting, two per cent. of metallic copper. The record of the Atlantic Mine is still more striking. It is opened on the ash bed, the uppermost copper-bearing bed of the series, a bed of amygdaloidal trap of great uniformity in thickness, of unusual softness, and through which the copper is distributed very evenly, though in very small quantities. The cost of mining and crushing is therefore low; and as hand sorting cannot be advantageously resorted to, machinery as automatic as possible is employed in every operation, which, indeed, is the case throughout the lake region.

The ore comes from a depth of over 2,000 ft.; is concentrated to what is termed mineral of a grade of 73 per cent. before being smelted, and is refined at one operation. The net yield of the ore is only 13 lb. of copper to each ton of rock stamped, or about 0·65 per cent. About 1,000 tons of rock are handled daily in the mill. The crushing is done by rock breakers and five heads of steam stamps, worked by cylinders of 18 in. diameter and 26 in. stroke under a pressure of 100 lb. of steam. The concentration is effected by 100 jigs with two sieves and fifteen slime tables. The ore as it comes from the stamps is sized in V separators. Ore, tailings, and concentrations are moved by water, of which 35 to 40 tons are needed per ton of ore treated. The labor engaged consists of one superintendent, ten stamp feeders, two head runners, two mill runners, four firemen, two mechanics, one blacksmith, two carpenters, chiefly employed in repairing the long flue and tail race, five laborers and spare hands, one sweeper and lamp cleaner, three wash bosses, one cooper, repairing and heading the barrels in which the mineral or concentrate is shipped to the refinery; in all 52 men, or one man to every 19½ tons treated.

The following summary of results I copy from the company's report for 1891:

Ground broken in openings and slopes	20,591·1 fathoms				
Rock stamped	297,030 tons.				
Product of mineral	5,089,700 lb.				
Product of refined copper	3,653,671 "				
Yield of refined copper per cubic fathom of ground broken	177·4 "				
Yield of rock treated, $12\frac{5}{16}$ lb. copper per ton, or	0·615 per cent.				
				s.	*d.*
Gross value of product per ton of rock treated		\$1·5467	=	6	5
Cost per ton of mining, selecting and breaking, and all surface expenses, including taxes		\$0·9529	=	3	11
Cost per ton of transportation to mill		0·0386	=	1	2
Cost per ton of stamping and separating		0·2583	=	1	1
Cost per ton of working expenses at mine		1·2497	=	5	2
Cost per ton of freight, smelting, and marketing product, including New York office expenses		0·1847	=	0	9
Cost per ton of running expenses		1·4344	=	5	11
Total expenditure for ton of rock treated		1·5451	=	6	5

Such admirable results are largely due to the administrative ability of Mr. Stanton, the general manager. But it would be a mistake to take the above figures as a criterion of what can be done when treating hard rock, such as is the conglomerate or even the harder traps. Low as the ore runs in copper, the company made, even in 1891, a mining profit of \$35,564.45.

The amygdaloid mines, however, if we except the Quincy, do not notably swell the lake production. But there is without doubt, on the amygdaloid beds, large tracts of such low grade ground as that mined by the Atlantic which could be profitably treated were copper to stand permanently at a higher figure. The cost of installation of a large lake plant is, however, so heavy as to impose caution on sensible investors.

The heavy producers are the conglomerate mines. It was not till 1864 that the Boston and Albany, disappointed by their operations on an amygdaloidal bed, turned their attention to the conglomerate. Their efforts were not rewarded by profits; but they attracted miners to a class of ore disregarded up to that date, and were the forerunners of the Calumet and Hecla, and the Tamarack. Though copper is so widely distributed through the several conglomerate beds of the Keweenaw series as to be almost a constituent of the rocks, and though so many attempts have been made to work them, success has attended the operations on only one long chute of ore, that which is known as the Calumet conglomerate. Elsewhere the conglomerates, though they carry in places a higher percentage than the richer traps, owing to their great hardness, have defied profitable exploitation. An indication of the limit of percentage which can safely be relied on as profitable is afforded by the Osceola, a conglomerate mine on the southern extension of the Calumet, from whose reports for 1891 may be gathered the following particulars:

The copper produced was 6,543,358 lb. from an ore which yielded 1·40 per cent.

The cost per ton of rock hoisted	\$1 83
Cost per ton of rock stamped	2 13
	cts.
Copper cost per lb. at the mine	7·63
Cost of smelting, freight, and all other expenses of handling copper	1·64
Making the cost per lb. of refined copper for the year, excluding construction	9·27
Cost per lb. for construction	0·84
Total cost per lb.	10·11

It will be remarked that the cost of mining and crushing the hard conglomerate, even under such excellent management as that as that of Capt. John Daniell, is much higher than those quoted from the reports of the Atlantic Company working on the soft bed.

Attention was attracted to the Calumet conglomerate by old Indian excavations. Work was commenced in 1865, and the mine rapidly rose to a position of supremacy, which was not challenged for 20 years. In its early days the mill yield was about 5 per cent., as then the ore was not sent to the mill with that indiscriminate impartiality which is practiced to-day, when the average yield is about 3¼ per cent. of ore, unselected within the mine or at surface. The net yield of the Tamarack ore, extracted from the same bed, at a lower level, is somewhat below that of Calumet and Hecla, being only 2½ per cent. of metallic copper.

This lower grade does not of necessity presage an average declension, owing to greater depth, but may be due to the fact that the Tamarack workings, whose extent as yet is very much more limited than those of the Calumet and Hecla mine, happen to have attacked a poorer section of the bed. The Calumet and Hecla does not publish the same minute statement of its operations as other companies from whose reports I have quoted, but, judging from the cost of treatment of the same class of ore by the Osceola and Tamarack companies, and from the character of the rock treated, we know that the cost of treatment of Calumet ore must of necessity be far greater than that, for instance, of any of the amygdaloid companies. The length of productive ground on the Calumet conglomerate as explored along its outcrop on Calumet and Hecla ground, and on Centennial and Osceola property to north and south, is about three miles; and exploration on the dip of the bed has determined the existence of ore to a depth of nearly a mile. Though Calumet and Hecla owns what seems to be the most productive portion of the outcrop, a large area of the bed on its dip is owned by the Tamarack, Tamarack Junior, and other companies and individuals. The Tamarack, encouraged by finding good ground in their first vertical shaft at a vertical depth of 2,270 feet, is sinking in the hope of cutting the vein and finding it profitable at a depth of about 5,000 feet.

At present this body of ore is tapped by twelve inclined and three vertical shafts on Calumet and Hecla ground, by five inclined shafts on Centennial, three inclined shafts on Osceola ground, and by two vertical shafts on Tamarack ground. In addition, Tamarack is sinking two very deep shafts on another section of their property, and Tamarack Junior is sinking below the limits of the Centennial company's property. Doubtless, as the ore chute of the Calumet conglomerate is limited along its horizontal extension, there is a limit to profitable ore in depth. If we assume however that the depth of the ore chute bears some proportion to its length, we have a body of ore, three miles long by say three miles deep, which at present price of copper can be profitably extracted. This alone will maintain the importance of the lake regions as a producer for many a year to come. The treatment of the conglomerate is effected by the same automatic machinery, arranged substantially in the same way as that employed in concentrating the amygdaloidal traps. As the Calumet and Hecla controls its own refineries, it is found more profitable not to run up the concentrates to as high a degree as that aimed at by some of the minor companies, whose mineral is smelted at so much per ton.

With regard to the probable discovery of other large mines upon this same series of copper-bearing rocks, all that can be said, in view of the fact that probably not one company in twenty organized since the incorporation of the Cliff Company in 1844 has paid a legitimate dividend, is that though the copper-bearing rocks in Southwestern Michigan and in Minnesota are largely developed and are known to carry copper *in situ*, and to yield considerable float copper ore, no profitable mine has yet been opened there, and facility for exploration is reduced by the heavily wooded character of the country, and the prevalence of low, swampy ground. It is fair, also, to assume that unless copper not only rises to, but maintains itself, at a high figure, new mining operations will not be eagerly engaged in within the present mining district by those best conversant with the risks of lake mining. At the same time it is consolatory to know that there are within those beds enormous resources of low grade ore, should that metal ever become scarce and valuable.

There are sulphureted ores of copper in both Michigan and Wisconsin outside of the Keweenaw series, but on none have mines of notable productiveness been opened. The lake mines possess the advantage of cheap water transportation to such distributing points as Chicago, Detroit, and Cleveland through the summer months, but they labor under the disadvantage of a frightfully rigorous climate throughout the winter. Abundance of timber, and what is even more essential to their automatic operations, abundance of water, distinguish them from the next group of mines which will claim our attention, viz., those of the Rocky Mountain zone.

Long before railroads gave access to the Rocky Mountains the existence in them of copper in large quantities was known. In fact, copper bars made from oxidized ore in Arizona were hauled as return freights by ox team, a distance of nearly 700 miles, to the terminus of the nearest railroad; and the richer argentiferous copper ores of Butte, Montana, were for several years hauled 400 miles to Corinne, the nearest station on the Central Pacific Railroad. Extensive operations were, however, forbidden by such costly transportation, and therefore the copper mines of the Rocky Mountains only sprang into prominence when reached by the transcontinental railroads and their branches.

In 1880 the Southern Pacific Railroad Company had pushed their Californian system across Arizona, and in the early part of 1881 made connection with the Atchison and Topeka Railroad at Deeming, New Mexico, thus giving ready access to the mines of Southern Arizona.

At the same time the Union Pacific was pushing forward a narrow gauge line from Ogden in Utah to Butte, Montana, which reached its destination in the fall of 1881. Thus almost simultaneously the great copper-producing regions in the extreme north of the Rocky Mountain zone and the extreme south were reached, and their resources rendered available. Hence the reason why the production of the United States jumped so rapidly at that period.

In 1879, the total production of copper of the United States was 23,000 tons, in 1880 it rose to 27,000, in 1881 to 32,000, in 1882 to 40,000, in 1883 to 51,000 tons; but the statistics for 1884 show a still more rapid bound to 63,000 tons, which was increased in 1885 to 74,000. This further augmentation was due to the discovery and rapid development of the Anaconda Mine in Butte. Since that date keen rivalry, and possibly a desire or a necessity to endeavor to make a certain aggregate profit, as the profit per ton decreased, by increasing the tonnage treated, has led the larger mines, pre-eminently the Calumet and Hecla, and the Anaconda, to increase their facilities and their consequent production, with results which have been acutely felt by the markets of Europe as well as of America. As it happens, although twelve years have elapsed since these Rocky Mountain mines were by railroad drawn within the circle of the world's commerce, no larger new deposits have been discovered or opened, although the Rocky Mountain system of railroads has in the interval been very widely extended. It has, of course, reached mines which were then known to exist, but excluded from active operation by reason of costly transportation—such, for instance, as the Verdi mines in Central Arizona. But it is a significant fact that, despite the greatly increased facilities, no large copper deposit then unknown has since been discovered and opened.

The Rocky Mountain mines may be subdivided into two groups: those of Southern Arizona and those of Northern Montana.

The ores heretofore yielded by Southern Arizona have been naturally oxidized, a circumstance which has compensated for their great distance from fuel, and for the absence of silver as a constituent mineral. They

are reduced to metal as 96 per cent. bars at one fusion, in water-jacketed cupola furnaces. Nature likewise, in eliminating the sulphur, has purified the ore from certain other obnoxious elements which are commonly associated with copper, and thereby enabled Arizona bars to take a higher rank in the copper market than most copper made from sulphureted ore. In fact, Arizona copper has heretofore held an intermediate position in value between lake copper, extracted from ore which nature by her own reduction and refining operations has converted into a metal of almost absolute purity, and copper made from sulphureted ores by artificial methods; which, rapidly applied, are less effectual in eliminating impurities than are nature's slow and thorough processes.

With insignificant exception, all Arizona copper comes from three groups of deposits: one near Clifton, another at Bisbee, and a third in the neighborhood of Globe. At Clifton the copper is made by two companies, the Arizona Copper Company, a Scotch organization, and by the Detroit Copper Company. At Bisbee the Copper Queen Consolidated Mining Company is the only large operator, and at Globe the Old Dominion Copper Company is the only present producer.

The ore occurs in all three districts in or adjacent to carboniferous limestone, which has been chemically and mechanically influential in assisting the oxidation of the ore to a very considerable depth; for through the crevices which intersect the limestone, and which have, in part, been the result of the ore decay itself, water has filtered down from the surface, and decomposed the ore to a depth of many hundred feet, and often far below the line of decay of the adjacent feldspathic rocks, unless where these rocks are themselves charged with copper. In Bisbee the ore bodies appear to be confined to the limestone, but follow no regular order in their distribution.

In Clifton and Globe, on the other hand, the ore bodies, though of irregular size and occurring at irregular intervals, are generally found in the plane of contact between the limestone and granite or the limestone and sandstone. Sometimes, however, and then over considerable areas, the granite and sandstone themselves are replaced by copper and associated ores. But even in these cases, the contiguous limestone has apparently played an essential part in the genesis of the oxidized ore. Sulphureted ores of copper are found in all of our extensively worked carbonate mines, some times in large masses, which from some cause, not always assignable, have escaped decay, occasionally even at a much higher level than that at which oxidized ores occur in the same mine.

The average percentage of copper in the ore it is difficult to determine, since unassorted ore is never delivered to the furnaces, while the grade to which it is selected is dependent in each district upon the cost of fuel and transportation. The furnace yield of Copper Queen wet ore is about 8 per cent., but almost as much very lean ore is stowed away in the stopes as is delivered to the furnace bins. The average ores of the other carbonate districts are probably richer, and their furnace yield is notably higher. The deeper Queen ores consist essentially of ferric oxide associated with cuprous oxide and cupric carbonate, resulting from the oxidation of iron and copper pyrites. They are consequently basic. But sufficient siliceous ore can be procured to supply the necessary acid flux for the furnace mixture. In the other districts, on the contrary, where the ore gangue consists largely of altered granites and sandstones, the siliceous and aluminous constituents have been imperfectly eliminated, and barren limestone must be added to the furnace charge. But in none of the large producing mines does the average of the ore reach the high percentage promised to investors in the prospectuses of undeveloped Southwestern mines.

The Arizona ore beds are characterized, as may be inferred from the above description, by great irregularity in size, distribution, and yield. In the Copper Queen mine a connection between one ore body and another can always be ultimately traced. But large sums are necessarily expended in exploration which often results fruitlessly. When large masses are found stopes of great size are often opened, and the ore being soft, the actual cost of breaking it is low, but, on the other hand, the expense of replacing all the ore extracted by heavy timbers built in square sets, and the cost of pumping with coal brought from a distance of 700 miles, raise the total cost of mining to a comparatively high figure, for lumber and wages throughout the whole Rocky Mountain zone are much higher than in the fertile and thickly populated States to the east or upon the Pacific coast to the west.* None of the Arizona companies publish precise statements of cost, but all those which are not encumbered by heavy fixed charges are known to have been prosperous of late years, and to have added very largely to their facilities for economical production.

None of the carbonate mines, however, have deemed it judicious to largely increase the production, which they have maintained at a very uniform figure for some years past. The only Arizona mine whose output has been greatly augmented during the past and present year is the United Verdi, a mine discovered and partially opened long before the advent of a railroad to its neighborhood rendered it possible to work it at all. It remained closed for some years after operations had been commenced, but has recently been resuscitated under vigorous management. In addition to the properties enumerated above, many copper claims have been exploited by public companies, but invariably without financial success. In other sections than those named, as well as in those sections themselves, there exist unquestionably large quantities of copper, but it is either contained in ore too lean to pay at present cost of beneficiation, or it is associated with refractory substances which forbid its treatment by simple and cheap methods of reduction, or it is too distant from market. These reserves, however, stand to the developed mines very much in the same relation that the leaner ores of the Keweenaw series stand to those of the great lake mines. With cheaper methods of treatment, lower freights or a higher price for copper, they may be available in the future, but are not likely to swell the world's production for the present. The total output of Arizona has never exceeded 40,000,000 lb.

A much more disturbing element has been the great mines of Butte, in Montana. As already explained, Butte came into existence as a producer simultaneously with the mines of Arizona, but instead of maintaining an almost stationary production, the record of the Butte mines has shown an extraordinary augmentation of yield from year to year. For while in 1882 Montana produced only half the copper that Arizona did, viz., 9,000,000 lb., as against 18,000,000 for Arizona, in 1883 Montana exceeded Arizona, producing 24,600,000, against Arizona's 23,800,000, and since then has, during every year except 1886, recorded so notable an advance in production that the 9,000,000 of 1882 is succeeded by 113,000,000 lb. in 1891.

Most of this large production comes from one bold vein, the most productive portion of which is owned by three exceedingly active and enterprising companies. The vein consists of a granitic filling impregnated everywhere more or less with mineral, and carrying masses sometimes of 50 and 60 feet in width of rich copper ore, associated always with more or less silver. From east to west the portion known to be productive exceeds three miles in length. As is the case with every large vein, there are portions where concentration has enriched it, and such a section as this case fell to the lot of the Anaconda Mining Co. While the vein varies in size and richness of copper, it also varies notably in the silver tenor of its ores.

Toward the eastern extension, in the Gagnon Mine, the ore is really rather a silver than a copper ore. In the next large property, the Parrott, the silver probably bears a slightly higher proportion to the copper than it does in the Anaconda and St. Lawrence. West of the Anaconda, in the property owned by the Boston and Montana, there is ore which yields copper with a very profitable amount of silver, but in most of the ore the silver has added heretofore but little to the value of the copper, being probably in about the proportion of half an ounce of silver to the unit of copper.

In places, rich silver and copper ores crop out at surface, but at the culminating point of the lode near the top of the hill, in the Anaconda and Mountain View mines, the lode was depleted of its copper to a depth of about 400 feet, leaving above that level an ore which was at one time regarded as a workable silver ore. The copper that had been leached out of this sterile tract was concentrated in a layer of exceptional size and richness which, when reached, enabled the Anaconda, through the rapid shipment of some 25,000 tons of rich ore, to spring almost into the first rank of copper producers. Beneath this layer of secondary ore in all the mines lies an unaltered ore necessarily of a much lower grade than the secondary ore, though carrying, if anything, a higher proportion of silver to copper.

The Anaconda Mining Co. makes no official statement. As their workings are much deeper than those of the adjacent property operated by the Boston and Montana Co., it may be assumed that the average of the ore treated runs lower in copper. In addition to the Anaconda and St. Lawrence, situated on the main lode, the Chambers Syndicate, which is a branch of the Anaconda Co., owns a large number of claims on parallel lodes and offshoots from the main lode. The product from all their mines is conveyed to Anaconda, a distance of thirty-two miles, where an abundant supply of water and an extensive plant allows of the concentration of over 2,000 tons of ore a day. The furnace treatment is effected in two establishments, where ores capable of producing highly auriferous matte are smelted separately from the ores of a lower silver grade. Heretofore the copper has been shipped in the form of matte of 60 to 65 per cent.; but there is at present in process of erection a large Bessemer and electrolytic plant of size sufficient to handle all the matte which the Baltimore Smelting and Refining Co. is not prepared to treat. It is expected that this large separating and refining plant will be in full operation next spring, and that, thenceforth, all matte shipments from that source to Europe will cease.

The company whose capacity for production in Butte follows that of the Anaconda is the Boston and Montana, which owns the eastern terminal claims of the great lode and a quantity of adjacent property. Their published reports convey the following information with regard to their operations during the year ending June 30, 1892:

Ore treated	151,489 tons.
Product of matte and shipping ore.	52,060,355 lb.
Product of copper	28,564,826 lb.
Product of silver.......	286,820 oz.
Yield of matte per cubic fathom of ground broken	5,809 lb.
Yield of copper per cubic fathom of ground broken....	3,188 lb.
Yield of copper per ton of ore treated........	18,262 lb.
Percentage of matte in ore treated.	16·64 per cent.
Percentage of copper in ore treated	9·13 per cent.
Copper in matte, cost per pound at mine	5·91 cts.
Copper in matte, cost per pound of freight, commissions, assaying, weighing, and Boston expense...	1·78 cts.
Copper in matte, cost per pound laid down in New York and sold.	7·69 cts.*

The area of good ground owned by this company warrants the belief that they will continue for many years to be very large producers of copper and silver. As in the case of the Anaconda, the necessity of separating the gold and silver from their matte, and thus securing the refiners' profit, has induced them to undertake the erection at the Great Falls of the Missouri, over 200 miles distant by railroad, of a very large concentrating, smelting, Bessemerizing, electrolytic, and refining plant. The works there will be propelled by water power, of which they have under control 2,600 horse power. The capacity of their concentrator is 600 tons per diem. The calcination of the ore will be effected in twenty-four Bruckner cylinders, and for its fusion into matte there will be used reverberatory furnaces of a tilting type, heated by gas, which will be made from the Sand Coulee coal, mined in the neighborhood of the Great Falls. A Bessemerizing and electrolytic plant is in course of construction, and, when completed, will be of a capacity to treat the company's total product.

There is a third copper company in Butte, of growing proportions, namely the Butte and Boston, which appears in the statistics or last year as making 18,134,343 lb. of copper—a production which it is likely to more than maintain in the future; for, though the company does not own a section of the main lode, it has a large number of very productive claims to the north of the lode, where the copper is usually associated with a higher proportion of silver than is the copper of the main lode itself. The Butte and Boston likewise proposes to convert its matte into metallic copper, and separate the silver by electrolysis.

The operations of the Butte and Boston show a large working profit, which has, however, been entirely absorbed by construction—and, in fact, the construction account of all the large Butte enterprises has been exceptionally heavy, and even when the works, as planned, are completed, will never be closed. But when the money saved by the more economical treatment of the ore in the large works, now in course of construction by the several companies, is added to the silver which will then be recovered, there is little doubt that the financial statements of the Butte companies will make a much more favorable showing than they do at present.

The activity with which mining is prosecuted in the immediate neighborhood of Butte is best illustrated by the fact that in the Silver Bow district about 5,000 mining claims have been patented, and the mines maintain a population of about 25,000 inhabitants.

Outside Butte no district promises, in the near future, to be a large producer. In Idaho, in the Seven Devils' district, there exist very promising indications of copper wealth, though, till exploited, its extent must be a matter of speculation. Nevada, Utah, and Wyoming have all yielded more or less copper, and all contain ores which, under more favorable conditions than exist today, will be utilized. Colorado stands in the list of producers as a State of growing importance. The deeper lead mines of the Leadville district carry in some instances a notable amount of copper, and copper is associated with the silver ores of several of the more southerly districts, and appears as a by-product in the returns of the lead smelters. Though Colorado does not possess any large mines of copper, properly so called, her production will increase rather than decrease. New Mexico is not a large producer.

Passing from the Rocky Mountain zone to the Pacific coast, California alone has been a notable producer, Oregon and Washington Territory having produced only hopes and reports, but no metal. California, as far back as 1864, shipped large quantities of ore, chiefly from the Union and Campo Seco mines of Calaveras County, which were opened on lenticular masses of sulphureted ore, embedded in slate; but, from 1866 till recently, these mines have remained closed. Operations, however, have been resumed, and the ore, instead of being shipped, is treated on the spot; and, therefore, California in the future will rank again as a producer, though not of a very high rank.

When we review the present position of the copper industry, we are struck by the fact that, though for many years no new mine has been opened, the larger and richer ones, which have been able to maintain existence in the face of depressed prices, are directing their efforts not so much toward increasing their capacity for production as toward reducing the cost of reduction, saving, as far as possible, the precious metals associated with their ores, and securing for themselves the profits which have heretofore been made by the refining companies to whom they sold their furnace material. The effect of this change of policy may tell upon the market. It certainly will affect the copper refineries of this country and the Continent. It would seem, therefore, that the era of rapid expansion is drawing to its close, and a healthier one of economical treatment is being inaugurated. The demand for copper is so great that, if this policy be pursued by the large existing mines, there will be room for the appearance of new competitors, without imminent risk of over-production.

While the production of copper the world over has gone on with leaps and bounds, the consumption has kept about uniform pace with it. At one time an old special use for the metal, such as for the sheathing of ships, has been abandoned, but at another a new use, such as for electrical transmission, has been created. Meanwhile, the demand for copper and its alloys for domestic purposes, for architectural decoration, and for the construction of machinery, has gone on steadily increasing. If we look back to 1850, in the United States, we find the consumption per head to have declined during only one decimal period, due, doubtless, to the revolution between 1850–60 in naval architecture, when iron ships supplanted wooden and copper bottoms. The following table is, at any rate, approximately accurate:

Year.	Population.	Consumption in Tons of 2,000 lb.	Consumption per head.
1850	23,191,876	6,710	0·550 lb.
1860	31,443,321	7,116	0·405 lb.
1870	38,558,371	12,342	0·608 lb.
1880	50,155,703	26,796	1·006 lb.
1890	62,622,250	94,800	3·02 lb.

Here in Great Britain the consumption per head appears to be even higher, for if the difference between imports and exports in 1880 and 1890 represents domestic consumption, the result is as follows:

BRITISH IMPORTS, EXPORTS, AND CONSUMPTION.

Year.	Imports.	Exports.	Consumption.	Population.	Consumption per head.
	tons.	tons.	lb.	1881.	lb.
1880	92,734	50,482	33,252	30,066,646	2·477
				1891.	
1890	141,249	89,747	51,502	37,740,283	3·084

* Miners' wages in Southern Arizona are from $3=12s. to $3.50=14s. per day. In Butte they are $3.50 per day. Common labor in both localities generally commands $2.50=10s.

* This would seem to be the cost after deducting what was received for silver.

Owing to the greater rate of increase of population in the United States, the increase of consumption there will be more rapid than anywhere on this side of the Atlantic, and therefore compensation will be provided against an increase of production on the North American continent. The trade, therefore, need not be apprehensive on account of increased average production. What is to be feared is such rapid and spasmodic augmentation as has characterized the past ten years. But, as we have pointed out, that was largely due to the sudden opening by railways of almost an entire continent known to be rich in minerals. Such extraordinary occurrences do not frequently repeat themselves. Yet, in spite of this, the balance between consumption and production, even in the United States, taken over a series of years, has not been very seriously disturbed.

There have been great annual variations, but the average annual increase in production of 14·53 per cent., and the average annual increase of consumption by 11·95 per cent., probably fairly express the growth of the trade in that country.

In speculating on the course of the copper trade, a peculiarity which should give stability to its movements must not be lost sight of, viz., that a comparatively small number of corporations produce the major part of the world's production. In the following table the production of the Anaconda mine for 1890 has been introduced instead of that for 1891, when it was closed for seven months.

TABLE SHOWING THE PRODUCTION OF EACH OF THE PRINCIPAL COPPER MINES OF THE WORLD IN 1891, AND THE PERCENTAGE OF THE WHOLE MADE BY EACH OF THE LARGE PRODUCERS.

	Tons of 2,240 lb.	Percentage.	Per cent.	Per cent.
United States	141,162	48·25		
Foreign	151,365	51·75		
World	292,527	100·00		
Rio Tinto	32,000	10·94	10·94	10·94
Tharsis	10,500	3·59	3·59	3·59
Mason and Barry	4,150	1·42	1·42	—
Cape Copper	5,000	1·71	1·71	1·71
New Quebrada	6,500	2·22	2·22	2·22
Chili	19,875	6·79	—	—
Mansfield	14,250	4·87	4·87	4·87
Japan	17,000	5·81	—	—
Australia	7,500	2·56	—	—
Boleo	4,100	1·40	1·40	—
Calumet and Hecla	29,018	9·92	9·92	9·92
Quincy and Franklin	6,497	2·22	2·22	2·22
Tamarack	7,231	2·47	10·31	10·31
Osceola	2,869	0·98		
Boston and Montana	11,958	4·09		
Butte and Boston	8,095	2·77		
Anaconda	28,600	9·78	9·78	9·68
Parrott	6,405	2·18	2·18	—
Old Dominion	3,138	1·07	1·07	—
Arizona Copper Company	3,000	1·03	1·03	—
United Verdi	2,942	1·01	1·01	—
Copper Queen	4,480	1·53	2·59	2·59
Holbrook and Cave	1,218	0·42		
Detroit	1,272	0·64		
Other United States	24,694	8·44	—	—
Other Foreign	29,635	10·14	—	—
Total	292,527	100·00	66·26*	58·15†

* Produced by 16 companies. † Produced by 10 companies.

Grouping together the Tamarack, Osceola, Boston and Montana, and Butte and Boston, which are controlled by the same shareholders, and the Copper Queen, Holbrook, and Cave and Detroit, which are managed from the same office, it would appear that ten companies make 58·15 per cent. of the world's supply and sixteen companies make 66·26 per cent. If we confine our view to the copper mines of the United States, we find that 37 per cent. of the world's produce is made by six American companies, or groups of companies.* The copper trade, therefore, in the United States, as elsewhere, has not escaped the universal tendency toward consolidation of capital in certain directions under a single management. In the case of the copper mining industry, the result has been brought about naturally and spontaneously.

* See *Engineering and Mining Journal*, July 23, 1892.

A NEW THAMES TUNNEL.

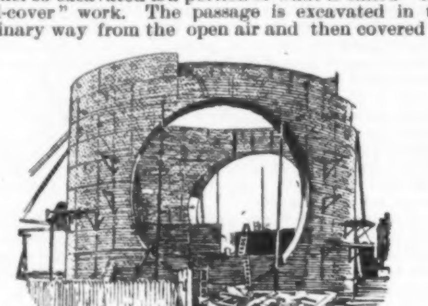
THE Blackwall Tunnel is one of the means the London County Council is adopting for joining together the sundered halves of Eastern London. Sir Joseph Bazalgette's original design for the tunnel was to make it of three tubes, two for vehicles and one for pedestrians. The Metropolitan Board of Works ceased to exist just before the contract for the work in this shape was sealed. Then the County Council took the matter in hand, and their engineer, Mr. A. R. Binnie, combined the three tubes in one. Going down the river, just past Blackwall and Bugsby's Reaches signs of the work in progress come into view on both sides of the river. On the north bank, in front of what is called Northumberland Wharf, adjacent to the Midland Wharf, the piles are driven for a new river wall, now about half completed. On the south side larger works are in progress, the most conspicuous object of which is the great iron caisson, or cylinder, which has been bolted together, plate by plate, to a height of about 50 ft., ready to be undermined by degrees and sunk into the ground to form one of the air shafts of the tunnel. Our illustration gives an idea of this caisson, showing the circular openings for the tunnel. They are not exactly in line, for the tunnel here makes a bend, and the caisson or shaft will form its elbow.

THE DIRECTION OF THE TUNNEL.

Commencing at the East India Dock Road, close to the dock entrance, the tunnel will run down the side of Robin Hood Lane, then, bending through a very flat S curve, will cross under the Great Eastern and Midland Railways and run down at the back of the houses in Preston Road. At the back of the houses in Preston Road is the first shaft of the tunnel. It here makes an angle, after which it runs to shaft No. 2, which will be sunk in the foreshore of the river in front of Northumberland Wharf, already mentioned. The Thames at this point is 1,200 ft. wide. Passing under the river at right angles to the stream, the tunnel reaches shaft No. 3, bears to the right in the direction of Greenwich Park, and through the reclaimed land known as Bugsby's Marshes reaches shaft No. 4, which is the caisson represented in our illustration, ending in Blackwall Lane, the main road connecting Blackwall Point with Greenwich. A new road from the end of the tunnel will strike the Greenwich and Woolwich Lower Road, thus making a direct thoroughfare from the East India Dock Road on the north to Greenwich and Woolwich on the south.

THE PLAN OF CAMPAIGN.

Three kinds of excavation are exemplified in the tunnel. The central portion under the bed of the river, which is naturally the most important, will be tunneled much as a mole bores his way along his subterranean passages, the process being that of a "shield" and compressed air. At each end of the portion of the tunnel so excavated is a portion of what is called "cut-and-cover" work. The passage is excavated in the ordinary way from the open air and then covered in.



NO. 4 CAISSON ON THE SOUTH SIDE OF THE RIVER.

Lastly we have the two ends of the tunnel, formed of open approaches, or sloping trenches down which the roadway runs. Here are a few figures starting from the East India Dock Road: Open approach, 785 ft.; cut-and-cover tunnel, 436 ft.; shield-driven tunnel, 821 ft. to shaft No. 1; ditto, 447 ft. 6 in. to shaft No. 2; ditto, under the river, 1,212 ft. to shaft No. 3; ditto, 602 ft. 6 in. to shaft No. 4; then a further section of either shield-driven or cut-and-cover for a distance of 611 ft.; cut-and-cover, 335 ft.; and lastly, an open approach for the south side, 860 ft. Under the river the tunnel is at a dead level; from the river on each side it rises about one foot in thirty-five. The contractors are just now at work on the open approaches and cut-and-cover. The shield-driving begins at shaft No. 4 on the south side, where the caisson is to be sunk. When the caisson has been embedded in the earth at its proper depth the shield will be fixed and will be gradually worked forward, the tunnel being built up ring by ring behind it to shaft No. 3, and onward under the Thames. It is possible, however, that another shield will be set to work from shaft No. 3, or shaft No. 2, on the other side of the river.

The shield may be compared to an air-tight steel box fitting on the end of the iron tunnel like the brass cap on the end of a telescope. Round the rim of this steel cylindrical box are hydraulic rams so constructed as to bear upon the tunnel itself as it is being built up behind them, thus forcing the shield forward as fast as the men at work in its face can remove the earth before them. The face of the shield is divided into twelve compartments, in each of which men will be at work with shovels removing the "ballast" under the bed of the Thames, and passing this earth behind them into the rear part of the shield, and so through the air locks into the tunnel itself, to be carried away. These air-tight compartments and air locks (like canal locks) are necessary to prevent the men being drowned or suffocated as they dig away the earth. The men work in compressed air at a pressure regulated so as to resist the pressure of the earth and water over their heads. The men in front will work under a pressure of possibly thirty-five or forty pounds to the square inch. Of course the work is dangerous and trying.

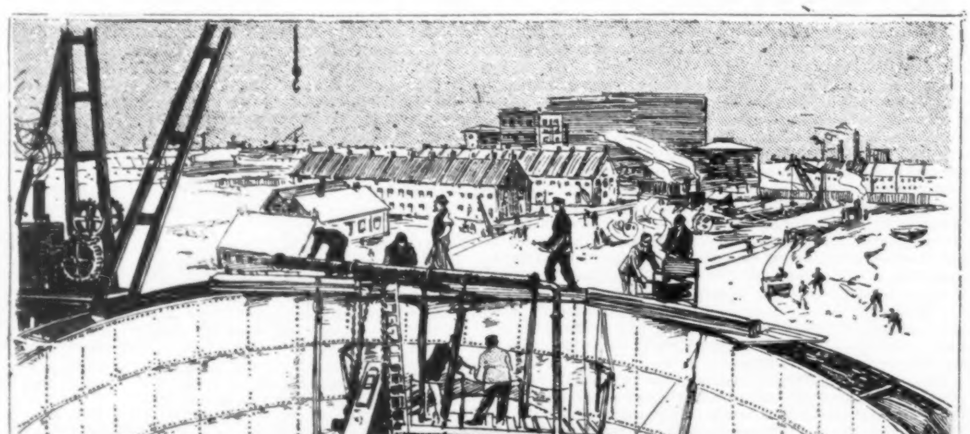
When the tunnel is finished—there are yet 2¼ years of the contract time of three years to run—the public will see a handsome arch of granite marking the entrance in East India Road. Riding down the open approach, with a footpath on either hand (in the tunnel the roadway will be 16 ft. and the footpaths 3 ft. 4 in.), one will enter the tunnel at High Street, Poplar, and will find one's self in a fine light arched road, with straight sides, granite nosing and plinth, faced with glazed tiles for the whole length. From Preston Road the pedestrian will be able to descend to the tunnel by means of a staircase in shaft No. 1; or again, from Brunswick or Yabsley Street he may walk upon the wharf and descend to the tunnel by a staircase in shaft No. 2. On the Greenwich side of the river, shaft No. 3 will have no staircase, being intended as a pumping station. Shaft No. 4 will have a staircase connecting the tunnel with Blackwall Lane. Backing the interior masonry will be a substantial lining of brick, and this brick tube will be itself inclosed in a tube of iron, bolted together in segments. The whole length of the tunnel will be 2,033 yards. The contract is for £801,000. About 20,000 tons of iron will be used and seven and a half millions of bricks.

About 300 men are at work already, and more will be engaged later. The shield, which has been made at Erith, will probably be in operation about Christmas. The chief work up to the present has been the construction of two great sewers in place of one old one, cut by the tunnel on the north side of the river. These sewers are themselves tunnels of no mean magnitude, and constitute a decided sanitary improvement. At Blackwall Cross the sewer excavators found, it will be remembered, a complete skeleton, buried twelve feet deep, with a wooden stake thrust between the ankles. As the stake was quite soft, like peat, the coroner's jury could not gratify local sentiment by pronouncing the skeleton as that of one of the Whitechapel murderer's victims. It will be an addition to the tunnel museum, in which are already some very curious small bowled pipes found in the mud.—*Daily Graphic.*

LOSS OF THE STEAMER BOKHARA.

OUR correspondent at Hong Kong sends sketches of the recent terrible catastrophe in the China Seas when the P. and O. mail steamer Bokhara was wrecked on the Pescadores Islands during the great typhoon of October. The sketches are from descriptions supplied at Hong Kong to our representative by Dr. Lowson, of the Hong Kong Civil Hospital, one of the survivors. As will be remembered, the Bokhara, with passengers and mails, was on her way from Shanghai to Hong Kong, when she encountered the typhoon. Just twelve hours after leaving port the sea began to rise and the barometer to fall. It continued to fall steadily, from 29·88 to 29·70, twelve hours later (midnight of Sunday, October 9), when Captain Sams had the sails furled and the ship laid to, the sea now running high and breaking over the ship. At daylight next morning (Monday, 6 A. M.) the barometer was at 29·55, and the sea and wind were terrific. Efforts to get the ship on the other tack failed utterly.

At ten o'clock it was blowing a full hurricane, the Bokhara rolling fearfully. The starboard lifeboat and jollyboats and the smoking room were now swept away, being followed a short time later by the other boats.



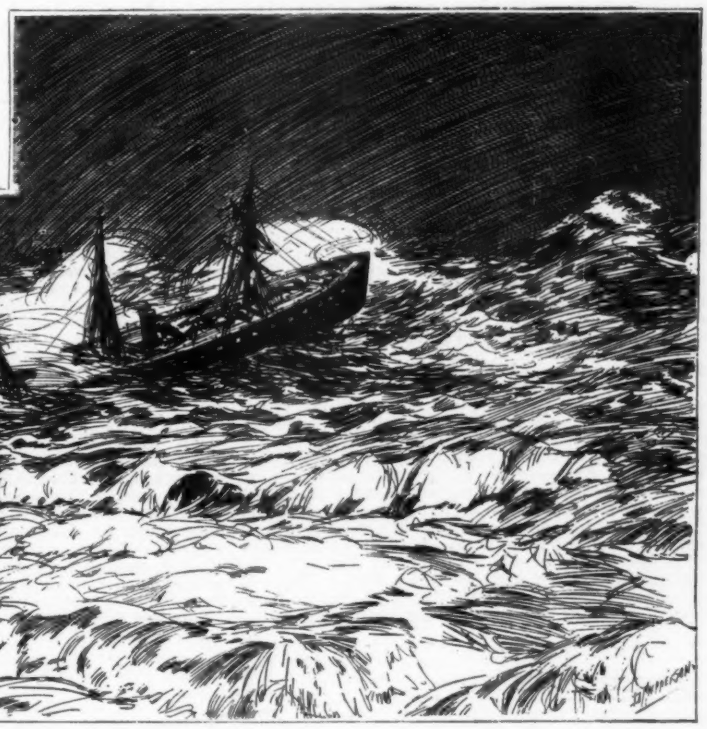
THE NEW THAMES TUNNEL—RIVETING ONE OF THE CAISSONS.

The sea now broke in the engine room skylight though battened down, but it was secured again quickly. Oil was now employed to pour on the waves, and this, for a time, kept the heavy breaking tops of the seas from coming on board. The glass, which at noon was at 29·27, at 4 P. M. was 29·15. It remained at this until the end.

At 10 P. M. three heavy seas broke over the vessel, breaking in all the skylights and the stokehold doors, swamping the engine room, and putting out the fires. The ship was now rendered unmanageable, but still the engineers were trying to relight the fires and get up steam again, when at 11:35 the land loomed up large on the lee beam through the drift. The reefs were soon plainly visible and rapidly nearing. Nothing more could be done though. Captain Sims himself bade his officers farewell, shaking hands with them all on the bridge. "Good-bye, we have done our best to save the ship," he said, and then he left the bridge and went to warn the passengers below that the end was at hand.

The next moment almost the Bokhara struck, grinding heavily with her broadside on to the reef and striking, as she rolled again and again, till her whole side was crushed and beaten in. The seas were bursting in cascades over all. The waves, in fact, washed those on the bridge and the upper deck on to the reef. Thus it was that the twenty-three who were saved, Dr. Lowson and Lieutenant Markham, of the Shropshire regiment, the first, third, and fourth officers of the wrecked ship, with two quartermasters and sixteen Lascars, had their lives preserved.

Dr. Lowson describes his escape as follows: "It is impossible to describe the terrible character of the struggle I had amid the rocks and breakers. Several times I thought all was up, and that I should never be able to reach the shore. Finally, I reached the shore with nothing on except my pajamas, which were all torn. I climbed a small hill and was literally blown down the other side. I fortunately came upon a little fishing hut. Nobody being in it I lay down inside, shivering with cold. About an hour later a dozen fellows, headed by Chief Officer Prickett, appeared upon the scene. We did not recognize each other at first. Finally, we all lay down on the sandy floor and passed a wretched night. At daybreak those of us who were able to move started out to forage. Fortunately, we soon came across a well, and some boxes containing some badly-damaged biscuits and candy. We also found a tin of tobacco. Some blankets and four rockets were also obtained from the wreckage. During our search Lieutenant Markham turned up, looking a dreadful object. On Tuesday afternoon, after tremendous exertions, we managed to light a fire by the aid of one of the rockets. Some seamen found several dead bodies on the shore, one of which they identified as Major Turner's. On Wednesday morning several fishing boats came in sight. I succeeded in inducing them to take us all to the village of Peho, where we were very well treated. On Thursday the mandarin at Makung sent for us."—*Daily Graphic.*



LOSS OF THE BOKHARA.—"A TERRIFIC WAVE EXTINGUISHED HER FIRES."

THE THEORY AND PRACTICE OF TANNING.

By WALTER J. SALOMON.*

I FEEL indeed highly honored to have been called upon to speak before your society as representative of an industry which has been known from time immemorial, is to-day one of the most powerful industries of the world, though of a modest bearing, and will be connected with mankind as long as human beings inhabit this earth. Leather manufacture and its collateral branches take fourth place in the list of manufactured products of the world, iron, wool and cotton alone taking precedence.

The dressing of leather extends centuries and centuries back. Herodotus, the historian, speaks of the Libyan women wearing goatskins stripped of hair and covered with vermilion. The Bible mentions the leather girdles of Elijah and John the Baptist. In the Mosaic account of the tabernacle we find reference to the rams' skins dyed red; while the Gordian knot, made of leather thongs, was cut about 330 B. C. On the doors of the Rochester (England) Cathedral, there were numerous skins of pirates; and so we can quote illustration after illustration showing the great age of leather manufacture in different shapes and forms. But we shall turn aside from retrospection and view the leather of to-day, its mode of manufacture, the results obtained and the why and wherefore of tanning.

First, What is leather? Leather is the result of the half chemical, half mechanical combination of the albuminous hide fiber and a substance which preserves the hide or skin and renders it pliable, thereby making it useful in the arts and manufactures. A great many different kinds of hides and skins are used in the manufacture of leather—cowhides, calfskins, horsehides, goatskins, sheepskins, kangaroo, alligator, lizard skins, etc. These hides or skins are purchased in different states; some are dry, some green—that is, just as they are taken from the animal—and some in the green salted state, to prevent decomposition in shipping.

Right here it will be interesting to become acquainted with the structure of the hides and skins used by tanners. The hide may be divided into three parts; namely, the epidermis, the coriin or cutis—or better still, the actual leather hide—and the lower flesh structure. The epidermis is totally removed in the work of preparing the hide for the actual tanning process; and the lower flesh structure is, as a rule, also removed little by little at different stages until we have the leather ready for the market composed wholly of the coriin or cutis.

The study of the formation and situation of hide fiber with the aid of the microscope is of great interest and a source of pleasure to the student. It is a remarkable fact that, as we divide or class the living animals according to their nature, in an exactly coinciding way can we class the same animals according to their hide fiber structure. Just as we class the alligator, snake and lizard in the reptiles on account of their similar mode of living, appearance, etc., so we find that they resemble each other even more in their fiber structure. The fiber of these reptiles is so much alike that it is almost impossible to distinguish any difference under the microscope. Again, the structures of the cowhide, horsehide, calfskin, deerskin, etc., resemble each other greatly, being of a looser nature than the fiber of reptiles. But in all hide structure we have the same method of growth and trend as in that of the development of the bark of trees.

The lower flesh structure is always of a loose nature, consisting, more or less, of loose bundles of fiber interwoven. As these bundles enter the cutis or coriin they become more compact, the weaving becoming of a closer nature; and as they near the grain or papillar the bundles disappear, and the single fibers are woven in a mass that becomes more solid, until it reaches the compactness of a horny grain which withstands the wear to which the leather is subjected. Just as the bark on trees is worked off and replaced by younger layers from the wood, so is the grain on the living animal continually replaced by fiber from the lower portions of the hide.

Leather is commonly divided into two classes; namely, sole and upper. We will first treat of upper leather. When the hides are received in the tannery they are soaked in water; this soaking removes all blood, salt and lymph substance, and softens the flesh still remaining on the hide so that it may be easily worked off with a knife. After removing the superfluous flesh the hides are resoaked for a period of two days, as a rule, and then placed in the lime. The lime is simply a solution of calcium hydrate or ordinary quicklime in water, and, like all alkalies, has the property of dissolving albuminous substance and distending fibrous substance. Upon this property is based the process of liming hides, as the action of the lime is a solvent one throughout, resulting in the loosening of the hair roots and the removal of the epidermis. The lime actually divides the fibers into numerous smaller fibers, a fact which is absolutely proved by the microscope. All of this work is done in the department called the "beam house," so called, evidently, from most of the work being done on beams. It will be seen that the tendency throughout all this work has been to cleanse the hide and hide fiber, and to remove all unnecessary flesh substance, leaving naught but the real hide substance or coriin. Heavy hides are usually limed from four to five days; but light skins of which pliability and elasticity are required are limed from eight to fourteen days. Glove leather is sometimes limed from twenty to thirty days.

Now comes an important step; this is the bating process. Before the hides are bated they are washed or rinsed well in water, whereby almost all of the lime is removed. The bate consists of manure, or if the raw material is a light skin—goatskin, for instance—fermented bran. The manures used are chicken, pigeon and dog. In the first place the effect of the manure bate is to dissolve and remove all the unnecessary interfibrous substances, leaving room for a freedom of motion of the fiber and facilitating the entrance of the tannin molecule. The effective principles of the manure bate are pepsin and pancreatine, substances which are formed in the body of the animal. While in Vienna last year I had occasion to make a comparative analysis of the strength of the various manures used by tanners, and I found that, taking chicken manure as 1, pigeon manure was 2 and dog 2½. The hide is put in a warm mixture of manure and water, and digested, as it were, until the hide is found to be "low" enough, or, in other words, digested to such an extent that a prolongation of the process would damage the grain or surface of the hide. This action of the bate may be prettily illustrated by taking an unclean piece of wet linen, halving it, washing one half and hanging both pieces out to dry. Upon examination the unclean piece will be found to have dried stiff and the washed piece to be very much softer. This is due to the untrammeled freedom of motion of the clean fiber. It has been very generally supposed that the purpose of the bate is to remove the lime, but as a rule the lime has been removed in the previous rinsings. Should small quantities of lime remain in the hide they may be dissolved out in the bate, as sulphureted hydrogen is usually present and transforms the lime into sulphide of calcium, which is easily soluble in water. The time of bating varies from four hours to a day and night.

Now, as to the bran bate and drench. The bran is usually set with warm water a day or two before it becomes necessary to use it. This brings about fermentation, in the course of which lactic, acetic and some butyric acid is formed. The amount of acid varies from ½ per cent. to 1¼ per cent. These acids will dissolve or remove lime, although lactic acid only suspends it; but the effective principle is not based upon this, but upon the plumping and distension of the fiber, thereby again preparing the skin for the actual tanning process. In fact, the test of the tanner is to make a sort of small balloon of the skin and press the inclosed air out, the ease with which this is done being used as a guide to judge the arrival at the wished-for result; namely, a porous, plump skin. An important factor in both of these bating systems is the action of those infinitely small animalcules, of which we know much, but actually very little—the bacteria. The effect of bacteria on the whole process of tanning is, in fact, of great importance, and furnishes a field for not only very interesting study, but also of practical research, with profitable results to the successful student.

In the bates the actions of the bacteria are absolutely uncontrollable, and this is the reason why this stage is so very difficult and requires constant watchfulness. The least change of temperature has an effect. For instance, a bate is placed at say 100° Fahrenheit in July. Now, in the ordinary course of events, the day temperature would be between 80° and 100°, and we might expect at night a temperature of about 70°. But should the night, instead of being cool, be close and warm, say about 80° to 95°, this would, first, increase the working powers of the pepsin, as the bate would not cool so quickly, and the greater the temperature the greater the dissolving power; secondly, the bacteria would propagate themselves at an enormously high rate, as a temperature of 90° to 100° is the ideal one for the propagation of these animalcules.

After the leather has been digested to an extent which is most satisfactory for that purpose it is intended to be used for, it is removed from the bate and "slated," that is, the hide is worked out with a slate set in a wooden handle. This removes all the so-called "impurities," which are really the interfibrous substances in solution and suspension. The hide is then ready to begin the process of actual tanning.

Now, as to sole leather. Hides suitable for this kind of leather are only the heavy cowhides and steer and bull hides. The hides are soaked in the same way; but many, instead of being limed, are "sweated" to remove the hair. Sole leather must be of a firm nature; therefore it is not necessary to have freedom of motion of the fiber, and consequently liming is done away with. The sweating is accomplished in a tight room which is full of vapor; this softens the hair roots, and within four or five days it is possible to brush all the hair off. Again, bating is unnecessary, and they are simply "wheeled" in water and then are ready to tan.

Right here it may be interesting to discuss the tanning materials in use throughout the world. Nature has again been great in her wisdom, for look where you will, from the heart of the United States or Europe to the interior of Africa, you will find substances containing available tannin in quantity. In the United States our main tanning materials are hemlock bark and oak bark, although other materials are used, which come almost totally from foreign countries. England produces only oak bark; France, oak bark and pine bark; Germany, the same; Austria-Hungary, the same, with the addition of knoppern, a small excrescence on branches, the result of the sting of an insect; Asia Minor, galls; India, catechu; Indo-China, gambier; Australia, mimosa bark, etc. There are hundreds of other tanning materials, but I do not wish to weary you by going into further details on this subject. The

* From the Technology Quarterly and Proceedings of the Society of Arts. Read May 26, 1892.

tannin contained varies from 7 to 70 per cent., and each and every one has its distinct color effect. Some tannins color red, others yellowish; again, some give a purple tint, others brown, etc. Some barks make a firm leather, some a loose, pliable stock; and as there is a continual international traffic in these materials, it has become the task of a good tanner to produce the best results in color and weight and firmness with all of them at his disposal.

We now arrive at a step of great interest. This is the actual process of tanning, in its practical as well as its theoretical phase. By careful study and continual examination of specimens with the aid of the microscope, the following conclusion as to the manner of tanning a hide and the entrance of tannin into the fiber is reached. The tannin molecules in solution in the bark liquor attack the hide from both sides, and first tan the outside fibers; then they are redissolved and go on to the next inner layers, their places being taken by other molecules. Now they leave the second fibers and go to the third, being again replaced, and so on, until the opposite armies of molecules meet, when the hide is tanned. The outside fibers are consequently tanned and retanned thousands of times. There is a condition which a tanner calls "dead tan," and this is based upon the total filling up of all the interfibrous canals, glands, etc. Tanners whose object it is to produce good weight results usually try to reach this "dead tan" point as nearly as possible and practicable. This theory may seem a little odd at first, but, as I said before, continual observation leads us to this conclusion.

Now, as to the practical side of this process. The bark or tanning material is placed in a wooden tank, or "leach," as the tanners call it, and water being pumped on it, a decoction is made. This gives us the so-called bark liquor, and in this liquor the hide is tanned. It takes all the way from six days to nine months to tan ordinary hides and skins, while a walrus hide requires a time of three years; this variation being caused by the different purposes for which leather is used, and the different peculiarities and qualities consequently necessary. In the case of light skins, by keeping them continually in motion by the aid of the paddle wheel, rockers, etc., so as to admit of the easy entrance of tannin, we are enabled to tan much more quickly; but these skins are used for light shoes and other light work for which no excessive firmness or solidity of the leather is needed. Heavy leather is, as a rule, "struck through," that is, colored through with tannin, and then placed in strong liquors or laid away in a pit and strewn with bark to tan for weight.

Of late years quite an industry has sprung up in the manufacture of extracts of bark for the benefit of tanners far away from bark regions, or to insure the tanner against a possible shortage of bark. The extracts are made by boiling the bark or tanning material with water in the open air or in a vacuum, and then boiling down to a thick mass containing about four to six times the strength of an equal quantity of bark. This, of course, is of great assistance to the tanner. But the correct use of these extracts is not quite as well understood by some tanners as might be wished.

There are also a number of other materials besides bark used for preserving leather. One might arrange tanning materials in a row in the order of their tanning ability, with tannins at one extremity, coloring matters in the middle, and aniline, which also preserves leather, as the least effective. It is a peculiarity of all metals of the third chemical group, namely, iron, chromium, aluminum, zinc, manganese—but nickel and cobalt excepted—that they have the property of entering into a half chemical combination with the fiber by the power called absorption, and thereby so enveloping the fiber that it becomes imputrescible. Alum tanning in different forms and processes has been in use for centuries, but chrome tanning, which is, as a rule, brought about by a soluble chrome salt being soaked into the skin and then precipitated on the fiber by reduction, has been in practice only since the year 1856. This tannage, as it is called, is being used to a large extent at present in the manufacture of glazed kid. Another tannage is made through the dongola process, which is a combination of the mineral tannage, the tannin tannage and the addition of oil or grease, usually in a saponified form. Again, we have the oil tannage for chamois and buckskin. Oil tanning is done by working the skins from the bate, usually bran, in oil, and removing the superfluous oil by soda or potash, or other alkali.

There has been much discussion within the last few years as to the real value of electric tanning, its real effect on the hide fiber, and its value in assisting and facilitating the tanning of leather. So far there has been no success made of this especial branch, although it has been tried in numerous places. A Parisian firm has been making numerous experiments for the last three or four years, but as far as I have been able to learn, has met with dismal failure. The idea that electricity can have any effect on tannin in any other way than to precipitate the phlobaphenes, that is, undesirable coloring matters, seems to me extremely doubtful. I have seen a number of experiments made with the aid of the different poles used, such as platinum, tin, gold, and copper, the peculiarity being that as the poles differed the color differed, one giving a bright and beautiful color, others giving darker colors. This may be of value to some tanners of upper leather or sole leather, who desire to obtain excellent color results. That the electricity has any effect upon the hide fiber is exceedingly doubtful; and as to its quickening the tanning, it cannot do so except indirectly by precipitating the undesirable coloring matter, thus leaving an easily soluble tannin which will pass into the hide at a quicker rate. But it requires constant care and study in order to obtain satisfactory results. Possibly new things may develop which may be of value, but for the present we can hardly call it an important phase of the leather industry.

There are thousands of ways of finishing leather after it leaves the tan, so that it will be impossible for us to go into this step any further than to say that most of the upper leather is colored black, worked out well to flatten it, and after being oiled is placed on the market.

It often seems strange to a person not connected with the leather trade that enough hides and skins can be procured to meet the demand for the many purposes that leather is used for; but instead of a shortage we have at present a large quantity in the market for which buyers are hard to find. The American leather trade is increasing yearly. Formerly we imported large quantities of leather, but to-day our import list has dwindled down to almost nothing, while we in turn are doing a very large export trade.

Before closing I would like to remark that all of the before mentioned theories have been made from actual observation in practice, not, as has been so often the case, by making theories and fitting practice to them.

The present opportunity to discuss the establishment of a technical school for the tanning industry is so good that I will pause a few moments on this subject. In Europe, and especially in this case Austria, they have carried the plans and ideas of technical education to a very successful point. You will find there schools and institutions of all special lines of industry; among them, most elaborate schools of forestry, inclusive of bark culture and economical production, and a most successful tanning school. The advantages of this technical education undoubtedly are apparent to this society. The leather industry of this country has reached a point where it must avail itself of the glorious advantages that the correct and conscientious application of science is capable of giving it. The associated manufacturers have appointed a committee to further this plan of the establishment of a school, but this committee have not met with the success in a pecuniary way that they hoped for. Now, it may be possible that such an annex or department of this institute could be founded here in the heart of the leather country, and the possibilities of the plan may furnish food for reflection for your society.

THE CONSTRUCTION OF MODERN BREECH-LOADING RIFLED MORTARS.*

By Capt. A. H. RUSSELL, U.S.A.

THE new use of mortars for coast defense was ably discussed before your society, last winter, by Colonel Mansfield, of the Engineer Corps of the army, and it will be unnecessary to dwell particularly on this point.

We have, however, many important things to consider regarding the manufacture of these engines of war, and this paper will be confined mainly to that subject. Experience with the castings made for thirty mortars at Providence and a number here gives, too, some valuable data regarding the Rodman process of casting, and throws some light on the question of using cast iron in the construction.

The modern mortar, shown in longitudinal section in Fig. 1, presents little likeness to the apothecary's mortar, which suggested the name for the old type, given in Fig. 2, showing on the same scale the old muzzle-loading, cast-iron mortar of 13-inch caliber.

The new mortar has more the size and proportions of a gun, as is seen by Fig. 3, giving the outline of a 15-inch Rodman gun, on the same scale. Its right to the name of mortar comes only from its similarity of use for throwing shells high into the air, to reach, from above, objects like the deck of a vessel, that could not be hit by the direct fire of high-power guns; the latter being effective only against the sides of the vessel. In shape it is a large howitzer, rather than a mortar; but being used like the old mortar for firing at much higher angles than was common with the old shell cannon called howitzers, it is called in this country a mortar, though often designated a howitzer abroad.

While the old mortar was a short, smooth-bore, muzzle-loading piece, throwing a spherical shell, the new mortar is a breech-loader, 129 inches long, nearly as long as the old muzzle-loading Rodman gun, and rifled in the bore to make it possible to throw an elongated projectile (indicated in outline in Fig. 1, in the firing position, nearly midway in the piece). The rotary motion given to the projectile by the twist of the rifling is necessary to keep the point of the shell in the direction of flight, much as the spinning of a top is necessary to keep it balanced on its peg. Going point on, the shell encounters less resistance from the air than if moving sidewise, and presents to this resistance a section no greater than the caliber, as with a round ball, while the added weight due to its length gives it greater inertia to maintain its velocity, and causes it to carry further than the round ball. A closer fit in the bore, too, is practicable with the long shell, as a copper band encircles the hard metal of the shell, and wedges into the rifling grooves, securing greater uniformity of motion in leaving the piece, and thus greater accuracy of fire.

The new piece, instead of being fashioned from a single piece of metal, like the Rodman gun, is, like the modern high-power guns, "built up;" *i. e.*, a central tube is encircled by hoops of steel, shrunk on so as to give a strength not practicable with the solid gun. Fig. 1 shows these hoops in section. Illustration is given in Fig. 4 of the principle on which this construction is based, as drawn from the law first worked out by Barlow for the resistance of hollow cylinders to pressure from within. The inner ring (shaded heavily) represents the section of a tube with walls equal in thickness to the bore. Suppose this to be enlarged by pressure from within until the bore gains the size of the original exterior. Assuming that the metal maintains the same volume, the exterior shaded ring shows the new section; and while the inner circumference is enlarged three times, the outer circumference is enlarged but little more than one and one-third times, showing that the strain on the inner metal is much greater than on the outer, as is evident from mere inspection of the figure. The law deduced is that the strain communicated to the metal varies inversely with the square of the distance from the axis. The inmost layer, therefore, might reach its breaking point before the outer metal, and a crack might be started within which would tear outward so that the tube would rupture before the full strength of the outer metal had been brought into play.

FIG. 4.—EXPANSION OF HOLLOW CYLINDERS.
Illustration of Barlow's Law.

If, however, each layer progressing outward were originally stretched slightly more than the one within, it is evident that the inner layers would be more supported by the outer layers against internal pressure, and the full advantage would be obtained when these strains were so proportioned that the layers would reach their limit of elasticity at the same instant. Then the tube would stand a much higher internal pressure than before. A tube so constructed with walls half a caliber thick (indicated by the dotted circle) would be one and a half times as strong as a ring of homogeneous metal a full caliber thick. Such a construction will evidently bring the inner layers into a state of compression; and this is a decided advantage, as they then can be expanded more before breaking than if in their normal condition.

This law of Barlow, so familiar to scientists, would hardly need to be recalled were it not that it is frequently asked, even now, why we should not make guns of one piece.

In practice, the law of variation of strain is more complicated than that given by Barlow, too much so for me to undertake its discussion now. Its application to army gun construction has been ably made by Captain Birnie, of the Ordnance Department of the army; but the old law, approximately correct, gives a striking illustration of the disadvantage of the solid gun; for, though such initial strains as are described can be produced to some degree in cast iron, yet they

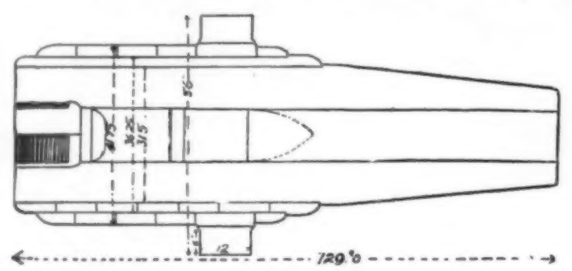


FIG. 1.
LONGITUDINAL SECTION OF 13-INCH BREECH-LOADING RIFLED MORTAR

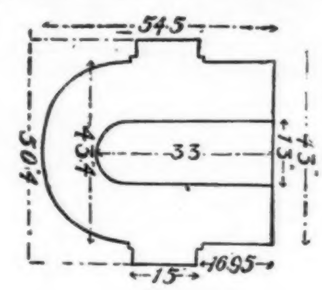


FIG. 2.
OLD 13-INCH MORTARS.

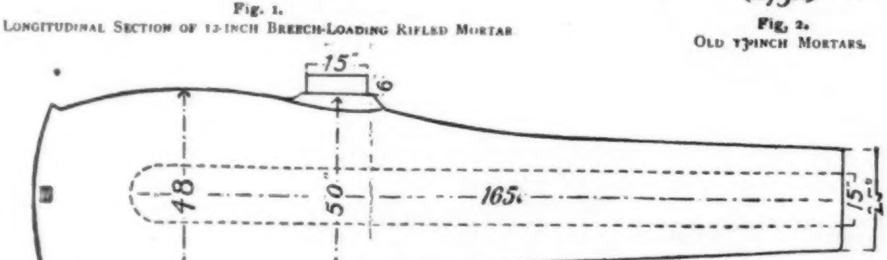


FIG. 3.—15 INCH RODMAN GUN.

* Read before the Society of Arts, Boston. From the *Technology Quarterly*.

cannot be as fully controlled as in the "built-up" guns.

While the ideal of tangential strength is secured more fully by wire wrapping, in which each layer is very thin, difficulties encountered in giving sufficient longitudinal strength by this method of construction have delayed its adoption, and the usual practice is to secure the desired condition, approximately, by the use of successive layers of hoops, made as thin as the conditions of manufacture allow, the great multiplication of very thin hoops being found undesirable.

In these mortars we have almost the only remaining example of the use of cast iron as a part of the system; for, while the modern high power rifled gun is made up wholly of steel, the inner tube or body of the mortars is of cast iron. The high pressures and strains in the larger guns put the use of cast iron out of the question for them; and even for mortars the all-steel construction presents some decided advantages, since

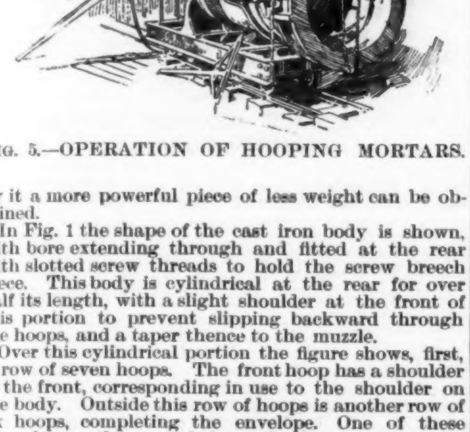


FIG. 5.—OPERATION OF HOOPING MORTARS.

by it a more powerful piece of less weight can be obtained.

In Fig. 1 the shape of the cast iron body is shown, with bore extending through and fitted at the rear with slotted screw threads to hold the screw breech piece. This body is cylindrical at the rear for over half its length, with a slight shoulder at the front of this portion to prevent slipping backward through the hoops, and a taper thence to the muzzle.

Over this cylindrical portion the figure shows, first, a row of seven hoops. The front hoop has a shoulder at the front, corresponding in use to the shoulder on the body. Outside this row of hoops is another row of six hoops, completing the envelope. One of these outer hoops, the second from the front, carries the trunnions, as shown in the figure. The hoops of each row are shrunk on, so producing the desired strain on the inner metal. Difficulties of construction make it desirable to use several short hoops in place of one long hoop or jacket.

The steel hoops, and other steel parts, are made at the Midvale Steel Works, Philadelphia, and sent, roughly shaped to size, to the contractors for finishing; forty-three mortars being under contract at the South Boston Iron Works and thirty at the Builders' Iron Foundry, Providence. These, with two or three more already built, are all for which Congress has made appropriation, out of the eight hundred needed for our coast.

Besides the steel hoops there are steel parts furnished which go to form the breech mechanism. This is of the interrupted screw type, commonly known as the French, but really the invention of Chambers, an American.

A full screw is cut on the cylindrical breech block, and then the screw threads are cut away parallel to the axis of the block at three points, leaving three spaces plain and three threaded, equal in width. The recess in the breech has screw threads similarly cut and slotted, so that when the threaded sections of the block are opposite the slotted sections of the breech the block can be pushed in. Then one-sixth of a turn engages all the threads. The threaded portion, of course, has to be longer than if the full thread were used, but in the latter case the block would have to be

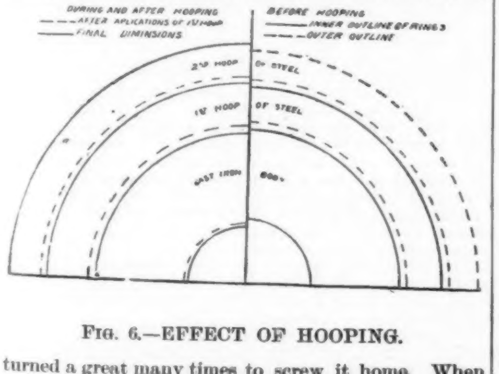


FIG. 6.—EFFECT OF HOOPING.

turned a great many times to screw it home. When pulled out, the breech block rests on a hinged tray, which swings to one side, uncovering the breech for loading.

The hoops are bored to a definite size, then the cast iron tube or body is turned to a diameter about five one-hundredths of an inch larger than that of the interior of the small hoops. These hoops are expanded by heat until they will slip over the body. They are put on from the rear, singly, and cooled in place; then they are turned off on the exterior with reference to the larger hoops, and the latter are applied in like manner. The front hoop of each row is forced forward to the shoulder, and the rear hoops are forced as close as possible to those in place, in order to make a continuous envelope.

The application of each row of hoops contracts the bore of the cast iron body six to eight one-thousandths of an inch, although the thickness of the walls is nine and one half inches.

By means of the star gauge the original diameters of the bore are measured at short intervals throughout the length, and remeasurements are made after each row of hoops is applied. The instrument is constructed as follows: Through a brass tube runs a sliding rod, having at the rear end a handle bearing a scale, by means of which, with a vernier on the rear end of the tube, the inspector can read off the movement of the rod. The front end of the rod terminates in a cone, and as it moves forward it presses outward two or

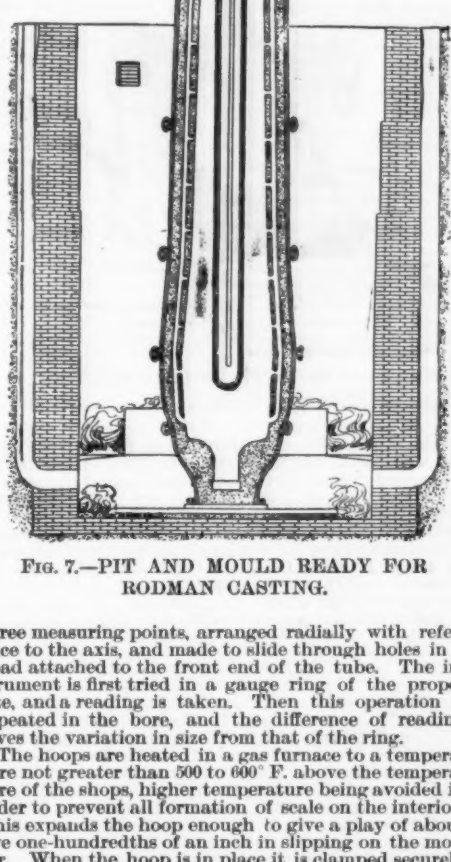


FIG. 7.—PIT AND MOULD READY FOR RODMAN CASTING.

three measuring points, arranged radially with reference to the axis, and made to slide through holes in a head attached to the front end of the tube. The instrument is first tried in a gauge ring of the proper size, and a reading is taken. Then this operation is repeated in the bore, and the difference of reading gives the variation in size from that of the ring.

The hoops are heated in a gas furnace to a temperature not greater than 500 to 600° F. above the temperature of the shops, higher temperature being avoided in order to prevent all formation of scale on the interior. This expands the hoop enough to give a play of about five one-hundredths of an inch in slipping on the mortar. When the hoop is in place it is clamped securely to the front of the piece by long side bars, drawn up powerfully by hydraulic or screw pressure, and a spray of cold water is at once driven against the outer surface to cool it.

The hoop is cooled at the front first, in order that it may nip there before it nips at the rear, as otherwise it might shrink away from the front hoop in cooling and leave a wide joint. The clamps are drawn tighter and tighter as the hoop cools, and they are released only when the hoop is firmly shrunk in place. Then another hoop is heated and put on.

Fig. 5 shows the apparatus for hooping, the mortar being horizontal during the operation.

Fig. 6 illustrates the different steps in the operation of hooping. In the portion to the right the figure shows the sizes of the body and the hoops before they are assembled; in the portion to the left, the effect produced by applying the hoops. By the application of the small hoop to the body, the body is compressed and the hoop enlarged. By the application of the larger hoop the body is still further compressed, the small hoop is reduced in size, but not quite to its original dimensions, and the outer hoop is enlarged.

Fig. 7 shows the construction of the mould for casting by the Rodman process of cooling from the interior, a current of water flowing through a hollow core. The mould forms a cylindrical cavity about sixteen feet deep, and the usual hollow core of the Rodman process runs down through the center. A pipe from above runs down within the core nearly to the closed bottom, and supplies a stream of cold water which flows up within the core, outside the pipe, and off by an escape pipe above. The metal stiffens enough in about twenty-four hours to allow removal of the core. The water is then admitted into the hole itself, though the metal of the casting is still at a red heat. The clay cover of the core is left in when the core is drawn out, and this forms a protective lining to the cavity to prevent excessive chilling of the metal. The figure shows the core extending only part way to the bottom with the mould following nearly the contour of the cannon, but the present practice is to make the casting cylindrical, and as the mortars are breech-loading, the core extends clear through to the bottom of the mould, where it is stepped into a depression, a pot of cast iron being sunk in the sand at the bottom of the mould, with the edge slightly projecting, so that the molten metal comes in

FIG. 8.—APPEARANCE OF CASTING WHEN TAKEN FROM THE MOULD.

contact with the edge, and forms a joint tight enough to keep the water from escaping after removal of the core. The metal flows down through runners in the sand of the mould, and runs in first at the bottom, side gates from the runners admitting it higher up as the mould fills. These openings are set oblique to the radius, to give a swirling motion to the metal in the mould, this making it easier to keep the impurities from sticking to the sides.

About twenty tons of pig iron and scraps of former castings are melted and poured in this operation, the reverberatory furnace being used. The cooling takes from seventy to eighty hours. A fire is kept up in the pit outside the mould to check the cooling of the exterior.

Fig. 8 shows the appearance of the casting when removed from the mould. It is a cylinder about thirty-four inches in diameter and fifteen and one-half feet long, with a rough bore about ten and one-half inches in diameter. The workman is represented as cleaning off the exterior.

The casting is made cylindrical to secure an approximately uniform strain of cooling throughout the casting. A length of about three feet is cut from the top, and five to nine inches from the bottom, or breech end, leaving room between for the body. This middle part is bored out and turned down to the proper size, tapered off at the muzzle, the weight being reduced to about eight tons.

The effect of cooling from the interior is to produce a compression of the metal near the core, and an extension of that near the outer surface, this effect depending on the rate of cooling, or the rate of flow of water through the interior. Exactly at what stage of cooling this effect is produced most extensively is not yet determined; but experiments are in progress to determine this, and to find by means of a new thermo-electric pyrometer the time when the molten metal stiffens. It is probable that the greatest effect is produced soon after the metal stiffens, when the water flows into the hollow itself, the surface exposed to cooling being much greater than when the flow is through the core. The theory is that the metal nearest the core stiffens first, and that the outer layers, forming later, and having to contract more in cooling than the partly cooled metal within, must compress the interior layers. Evidently it will be impossible for the outer layers to shrink the normal amount, and they will be stretched like the outer hoop shown in Fig. 6. The metal close to the exterior, however, which may stiffen earlier from

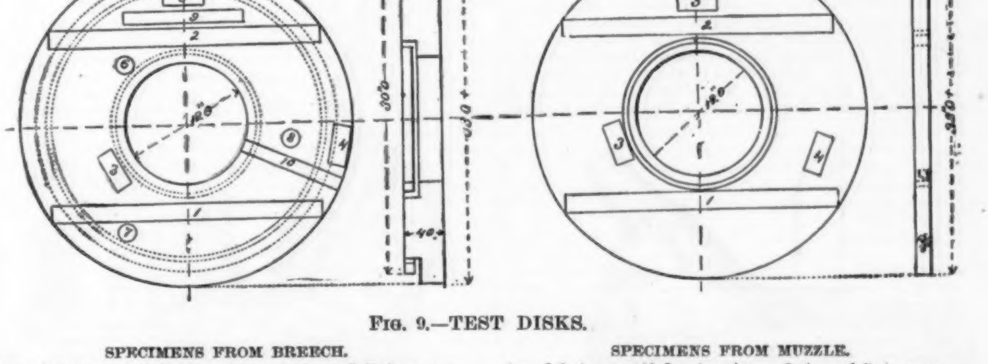


FIG. 9.—TEST DISKS.

SPECIMENS FROM BREECH.

1 and 2, tangential extension. 3, 4, and 5, tangential tenacity. 6, 7, and 8, longitudinal tenacity. 9, tangential compression. 10, radial compression.

SPECIMENS FROM MUZZLE.

1 and 2, tangential extension. 3, 4, and 5, tangential tenacity.

radiation of the heat to the outer walls of the mould, seems to show a reversal of these strains. This outer skin is turned off, and measurements of tension are made only on the layers corresponding to the inner and outer ones of the finished body.

Test disks, shown in Fig. 9, are cut from the castings close to the top and bottom ends of the body; and the three rings there shown, having a section of one square inch, are removed from the disks, the diameters of these rings being measured before and after removal.

The inner ring at the breech must expand enough to indicate an original compression at the bore of from 5,000 to 9,500 pounds per square inch; and the outer ring must contract, the strain of the exterior iron usually being about 4,000 pounds per square inch. Only a

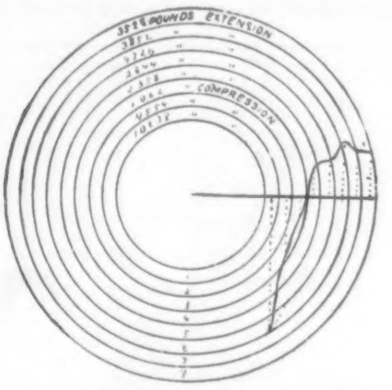


FIG. 10.—STRAINS IN RODMAN CASTING.

Distances below horizontal line indicate compressions. Distances above horizontal line indicate extensions.

small ring is removed from the muzzle end, and this must indicate a compression lying between 5,000 and 13,000 pounds per square inch, the initial tension being usually greater near the top than near the bottom. The reason for this difference is not clear; but it may be due to greater heat at the top of the pit, outside the mould, than at the bottom, allowing less exterior cooling of the casting at the top.

Fig. 10 shows a disk taken from the muzzle end of one casting, and cut into eight successive rings. At

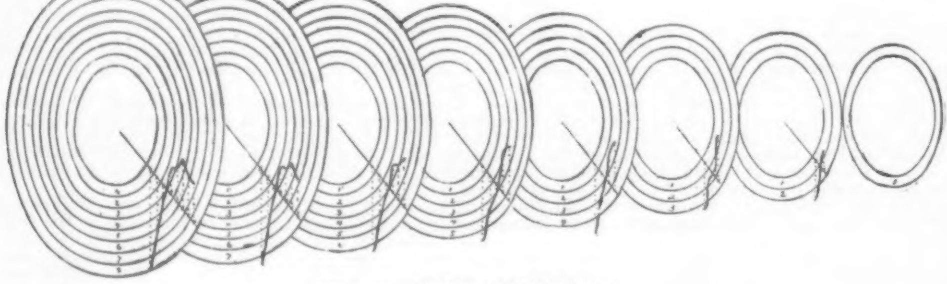


FIG. 11.—RODMAN CASTING.

Change of Strains as Outer Layers are Removed.

Distances below oblique lines measured on dotted lines indicate compressions.
Distances above oblique lines measured on dotted lines indicate extensions.

the right the curve of strains is shown, the distances below the horizontal line indicating compression and those above indicating extension, the neutral point being just outside the third ring from the bore. It is to be noted that the outmost ring shows the reduction of strains mentioned above. It appears undesirable, therefore, to leave the outer skin on a finished gun casting, as a line of weakness may be expected a little below the surface.

The old method of determining initial tension was to cut the entire disk through radially at one point, as at the horizontal line, for instance; and to calculate the tension by the variation in the opening from the width of the original cut. Inspection of the strains indicated in the diagram shows that the variation in the radial slit in the old method gives merely the resultant effect

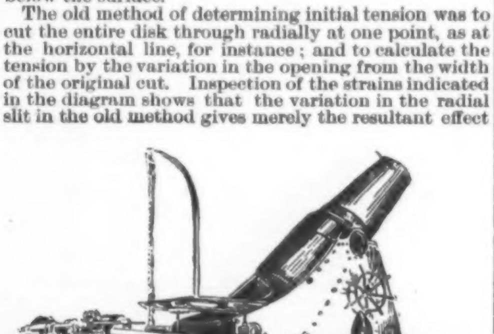


FIG. 12.—B. L. MORTAR, OLD FORM OF CARRIAGE.

of many varying strains throughout the disk, and no data for calculation of the strain at any particular point of the disk.

The old theory was that the strain of extension on the exterior was equal to that of compression at the bore; but new results show that the former is much less than the latter, and that proper measurement would give about half the compression supposed to exist at the bore in castings tested only by the old method.

The new method is due to Captain Crozier, of the Ordnance Department of our army, who, a few years since, at Watertown Arsenal, removed a full disk from a casting and cut it into rings, measuring the expansions and contractions; applying to cast iron methods used by General Mayevski in Russia, and later by Noble in England, for determining strains in steel hoops.

At Providence the process was carried a step further

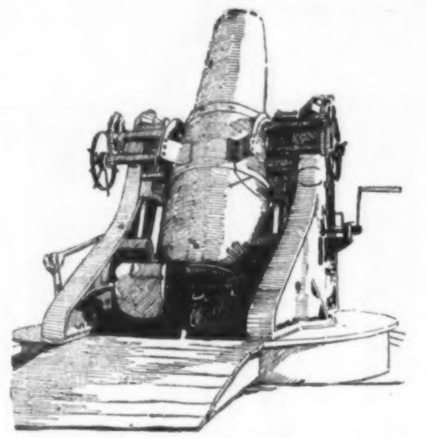


FIG. 13.—THE 12 INCH B. L. MORTAR.

Mounted on the "Easton & Anderson" Carriage.

than by Captain Crozier, in that measurements of the rings were made, not only before removal of any from the original disk, and after the separation of the rings, but in the disks of varying sizes left by cutting off exterior rings. This made it possible to determine the tensions in disks of varying diameters, corresponding to the sizes at different points of the tapering muzzle. The result is given in Fig. 11. This shows how the compression of the inner metal decreases as the outer rings are removed, except, perhaps, for the removal of the outmost ring. Also, how the neutral point remains just outside the third ring until the fifth ring is removed, when it shifts to a point between the second and third rings, and the third ring becomes stretched instead of compressed. A reversal again takes place when the third ring is removed, and the second ring becomes stretched in a disk of two rings, the neutral point lying between them.

These recent results of careful and suitable measure-

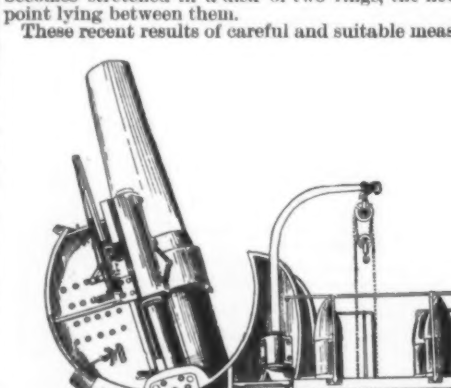


FIG. 14.—WHITWORTH MOUNTING FOR HIGH-ANGLE FIRE.

ments bear out fully the theory of Rodman respecting the advantage of cooling cast iron guns from the interior, and confirm his genius. Observing the opposite effect in solid cylinders, necessarily cooled from the exterior, where the inner metal tends to become spongy, being drawn outward by clinging to the outer layers, which stiffen first, he introduced the new method to secure sound metal near the bore, and to produce advantageous strains, the old method producing directly opposite strains. The effect of cooling from the exterior is particularly apparent in chilled rolls, which often break apart under the strains produced, and show cavities within.

Even cooling from the interior may be carried on so rapidly that excessive strains will occur, causing rupture at the outer surface; and this has been illustrated in many gun castings, which have burst asunder in the lathe, or even in the mould.

Though tests of specimens cut from the casting near the bore do not necessarily show an increased density, it is probable that the density is increased in the casting itself, the specimen when free recovering its normal size, not having been compressed beyond its elastic limit.

Fig. 9 shows the muzzle and breech test disks marked off to show where specimens are to be taken for test: the long ones for elongation and compression, and the short ones for tenacity, density, and hardness. The latter are arranged at different distances from the

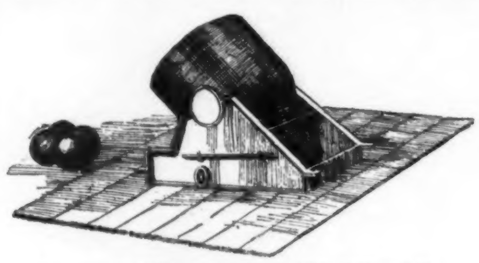


FIG. 15.—13 INCH SEACOAST MORTAR, SMOOTH BORE.

center. No definite law of variation of tenacity has been found; but the lowest tenacity in any one disk is apt to be found in the middle, and the muzzle (near the top of the casting) usually runs higher than the breech. The head of metal seems to give very little advantage. There is the same lack of regularity in density and hardness, but the hardness is usually greatest at the top.

The tenacity must lie between 28,000 and 37,000 pounds per square inch, with an average of at least 30,000 pounds.

Figs. 12 and 13 show the United States mortar mounted on its carriage; Fig. 12, the old form of carriage, without provision for taking up the recoil; Fig. 13, the modern carriage, described by Colonel Mansfield, where the recoil downward in an oblique direction is checked by hydraulic or pneumatic buffers. Fig. 14 shows the Whitworth carriage with a mortar of English pattern. Fig. 15 shows the old fashioned mortar, mounted for firing.

In this connection it may be said that the old idea of the importance of great weight in cannon to lessen recoil does not apply particularly to mortars, since the methods for checking recoil and reducing the shock on the carriage have been so fully developed. On the other hand, since the mortar has to be restored to its firing position by means of springs which are not required to bear the full effect of the recoil, advantage in reduced length of springs can be obtained by having a lighter mortar. This would be given by the all-steel construction now proposed, and at the same time a more powerful piece would be obtained, throwing a shell of eight hundred pounds six miles, instead of a shell of six hundred and thirty pounds five miles.

CHLORINE AND SODA BY ELECTROLYSIS.*

By E. ANDREOLI.

SOME time ago there took place an evolution in the process of bleaching by electricity. It is not in France, nor even on the European Continent, where this sudden growth has taken place. It is in England and America where the attempts on the large scale at bleaching with electrolytic hypochlorite have been abandoned.

The reasons why the paper manufacturers have given up the use of the hypochlorite produced by electrolysis are most natural and well founded. Here are figures given by a paper manufacturer. To bleach a ton of raw alfa or half a ton of paste, 256 gallons of bleaching liquor (=1,152 liters) at 6° Tw. are required, representing 18·7 grammes chlorine per liter. These 1,152 liters are poured into the pitcher with 2,068 gallons (=9,361 liters) water, and of this large quantity we recover only 2,524 liters, the rest being lost in the manipulation.

If, instead, we use a hypochlorite produced by the electrolysis of magnesium chloride, the loss is enormous.

The reversed electrolysis for the recovery of the hypochlorite, in addition to great practical difficulties, leads to the production of chlorate.

The Greenwood process has been attempted at the Phenix wharf, Battersea. This establishment is now closed, and it is not known if the Chlorine and Caustic Soda Syndicate will reopen it.

The process of Richardson and Holland is being worked by the Electrolytic Caustic Soda and Chlorine Trust, at Snodland, on the Medway.

The works there include a steam engine of 150 to 200 h. p., and a Gulcher dynamo giving 70 h. p. The salt store contains 100 tons. At the top of the works is a large tank in which the salt is dissolved with the aid of an agitator. The solution descends through pipes into a series of ten vats, each of which is twenty feet long, three wide, and nine inches deep. Each vat is divided into sixty compartments, thirty for the anodes and thirty for the cathodes. The current traversing them is four hundred and fifty amperes. The electromotive force is forty-four volts at the clamps of the dynamo. The loss on transmission is four volts. The chlorine is passed into two lead chambers, where it is absorbed by lime, forming chloride of lime. The solution of soda formed at the negative pole is three times stronger than that commonly used. It is employed as a liquid, which is a great economy in fuel and labor.

* *Bulletin des Fabricants de Papier; Electrical Review.*

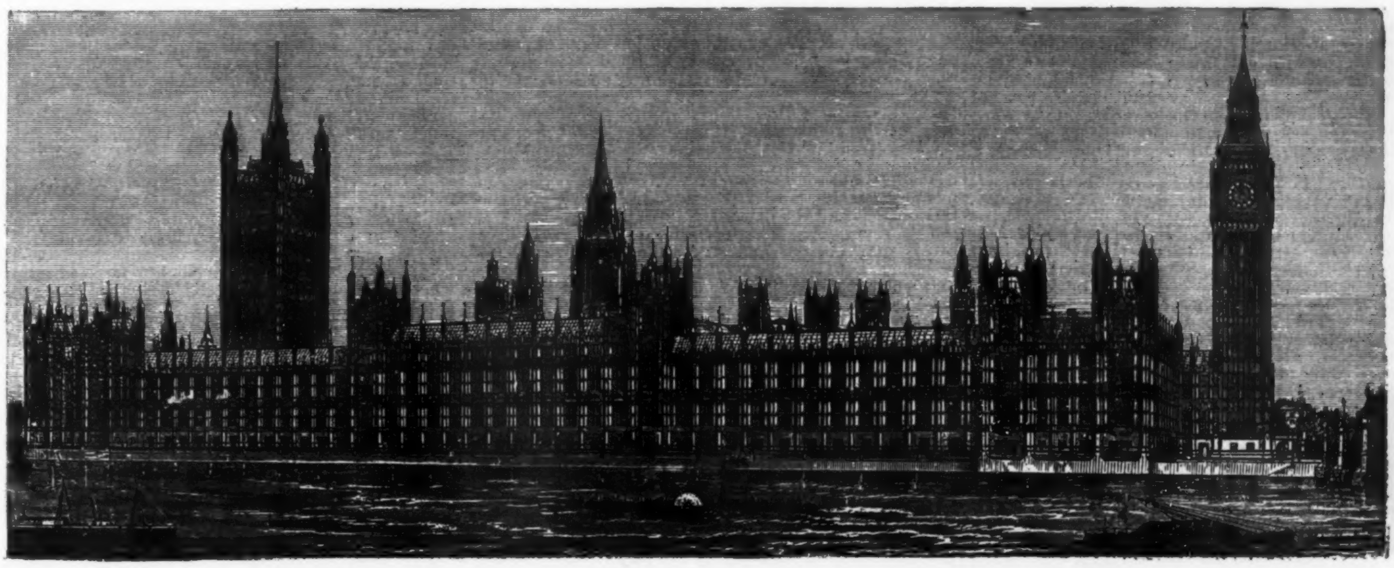
THE HOUSES OF PARLIAMENT.

WE illustrate herewith the Houses of Parliament, for which we are indebted to *Industries*. The old Houses of Parliament were very small and inconvenient, as well as totally unfit in point of magnificence for a powerful nation like England. This fact was recognized, and many plans for altering or reconstructing the existing edifice were submitted, but no definite action was decided upon until the old building was destroyed by fire in 1834. Mr. (afterward Sir) Charles Barry was selected as the architect, his plans being chosen out of ninety-seven submitted. England was at that time in the midst of the Gothic revival, which was commenced by the erection of Strawberry Hill House and Fonthill Abbey. The craze affected all classes of society, so that the parliamentary committee made no objection to, and, in fact, selected the Gothic style.

The great building was erected in the richest late Gothic or Tudor style, and the exterior was built of magnesian limestone, from Auston, Yorkshire, and the interior of Caen stone. The exterior has suffered greatly from the London climate, and is a constant source of expense for repairs. The Houses of Parliament, or the new Palace of Westminster, as it is called, covers 8 acres, and contains 1,100 apartments, the cost being about $15,000,000. The illustration gives a view of the water front, which is very imposing, being 940 ft. in length. The palace yard front is not as regular as St. Stephen's Hall, the great hall of William Rufus, which will be ever memorable as the place which witnessed the greatest trial ever held—that of Warren Hastings. From a distance, the salient feature of the structure is the Victoria Tower, used as the entrance for the sovereign. This tower, which is 340 ft. in height, dwarfs the rest of the structure. The bell tower contains the well known bell "Big Ben."

The interior is divided into two nearly equal divisions, one part for the Lords and one for the Commons. The interior of the House of Lords is very rich and elegant, and the House of Commons hardly less so. Space forbids a description of the woolsack, the mace, and other paraphernalia with which the English lawmakers are burdened, and it is hardly necessary to say that the whole of the proceedings are very curious to American eyes. The other rooms are in keeping, and the English lawmakers are probably more comfortably housed than any other legislative body, and the wants of the inner man are attended to with the greatest care.

The Houses of Parliament are somewhat severely criticised by Fergusson and others, but, on the whole, it is perhaps the best effort toward the application of mediæval architecture to secular purposes, though the result is hardly as satisfactory as the renaissance capitol at Washington or the splendid *Palais de Justice* at Brussels, which may be regarded as the most successful modern building from an architectural point of view.



VIEW OF THE HOUSES OF PARLIAMENT FROM THE RIVER.

THE EPIDEMIOLOGY OF CHOLERA.

By Dr. G. ARCHIE STOCKWELL, F.Z.S. (of New Sydenham Society, London).

THE medical world is to-day as ignorant of the primary derivation of epidemic cholera as ever, though many hypotheses are not wanting. It is possible, perhaps even probable, that in its natural home, in the great river deltas of lower Bengal and of Siam and Burma, where it is endemic, it results from *miasm;* but whether or not this miasm is developed on diseased rice, as has been suggested, it must be admitted the disease, in its more malignant form at least, was originally exotic to Europe and America, and even now depends for its vigor more or less upon the constitutional dyscrasiæ of individuals, and for its persistence upon certain telluric, meteorologic, atmospheric, and concomitant unsanitary conditions.

It is especially noticeable, all other things being equal, that the malady flourishes best—that is, attacks more people, is more fatal, and more rapidly extends itself geographically—under two special conditions:

First—During a high temperature of air and earth.

Second—At periods when the variations of ground, water, and temperature are capricious, abrupt, without warning.

Thus in October and early November, perhaps, in the northern temperate zone, when the majority of people are day by day vacillating between light clothing and heavy wraps—when colds, influenza, and malaria are especially rampant, and other diseases prevalent that are the outcome of carelessness, deficient body temperature, or overheating—the ravages are apt to be greater than in December, when heavy clothing and heated houses are the rule. So, too, the disease is more active in July and August, when the days are insufferably hot and the nights cool with heavy dews, than in either September or June. Again, the history of the epidemic in Asia, Europe, and America evidences that in high and dry situations, in cold climates, wherever there is a moderately uniform or gradually progressing or regressing temperature during the twenty-four hours, its spread in the main is limited and slow; while in low-lying, moist places, especially in hot climates, that present extremes of humidity between meridian and the succeeding sunrise, its ravages are apt to be most severe, and oftentimes quite uncontrollable. In both farther and hither India it has been observed the pestilence suddenly springs into activity with the arrival of the southeast monsoon, which, charged with humidity from the Pacific Ocean, frequently causes a fall in temperature of as much as fifteen to thirty degrees within almost as many minutes.

Further evidence of the part played by telluric, meteorologic (and likewise astronomic) conditions is had in the fact that, when cholera is endemic to volcanic regions it becomes more active and virulent in those seasons when there is an accession of volcanic action, or when such is pending; the disease was exceedingly active and pernicious throughout the Indian Archipelago and the Malay Peninsula after the Sumbwa eruption, and all enteric maladies of choleraic nature were then greatly increased and obtained new impetus. In middle and eastern Europe, when the epidemic of 1830-34 was at its height, it was observed birds, quadrupeds, and even insects suffered, both prior and during the epidemic, from unknown maladies that caused their death in great numbers. The same was true in India, also of the United States, in varying degree, according to topographical features and surroundings. Dr. O. D. Norton, of Cincinnati, recalls that in that city, in 1849, when cholera was especially virulent, birds died in their nests, and even house flies and mosquitoes were exterminated. The same phenomena have accrued to certain portions of Europe the present year. Again, each cholera epidemic that swept the civilized world has been preceded or accompanied by profound disturbances within the solar system, and by evidences of famine. Finally, the great epidemics of influenza of this century, though their appearance may be coincidences merely, are certainly suggestive in that in each instance, viz., in 1805-32, 1847-49, 1851-53, 1864-65, 1890-91, they preceded an epidemic of cholera. Sir Thomas Watson especially notes this fact, and John McLean, for twenty-five years a Hudson Bay factor, observed the same in the Peninsula of Labrador, where the natives (Nascopies and Innuits) were first decimated by influenza, then ravaged with an epidemic of choleraic character; further, it is somewhat striking that both maladies, to use the words of Watson, "issuing from their cradle in the East, traversed the northern countries of Europe till, arriving at its western boundary, they divided into two great branches, the one proceeding onward across the Atlantic, the other turning in a retrograde direction, toward the south and east." Between the two epidemics, moreover, there is marked similitude or analogy, the main differences being that, whereas one spared but very few and was seldom fatal, the other smote very few, but with so deadly a stroke that the death rate was exceptionally high. Both are in a sense general epidemics, affecting the whole system, but especially manifest in the nervous portion; in both the most prominent symptoms are referable, in the majority of cases, to the mucous membranes—to those of the air passages in influenza, to those of the alimentary canal in cholera.

Surgeon Majors T. R. Lewis and D. D. Cunningham, who investigated cholera in India for eleven years consecutively (1869 to 1880) under orders from her Majesty's Secretaries of State for War and India, remark* that in manifesting a marked partiality for a soil of the character of the Brahmaputric and Gangetic alluvium, "cholera is by no means singular, for it is a well established fact that malarious fevers and kindred disorders flourish with most vigor about the deltas of large rivers all over the world," . . . but they would not, however, "be understood to imply that the causes productive of malarial fevers and cholera are identical, or that the localities providing the conditions necessary for the development of the one must necessarily provide those for the other also."

Speaking of the Andamans, where this malady has never flourished and malaria is always rampant, Dr. Lewis says: "Notwithstanding the islands are within three days of India and twenty-four to thirty-six hours of Burma, and that during the last twenty years steamers have constantly passed between the two countries and the settlement, . . . it is only on rare occasions that cases of cholera have been registered as occurring."

Of these rare cases, Dr. Rean, principal medical officer of the settlement, says: "The patients were generally admitted from some feverish locality, or had been employed on works of an unhealthy character."

The importance of well authenticated cases of this nature can scarcely be overrated in connection with the ætiology of cholera; they strongly evidence the correctness of the views promulgated by both Charles Macnamara* and Max von Pettenkofer† and assimilate, so to speak, the two. Questions of possible infection or of water contamination by specific imported material can hardly be seriously entertained here. With the restrictions surrounding this isolated convict settlement, there can be no casual importation of cases, as the recent history of every person is accurately known. Similar seizures, moreover, occur habitually in every city of India, as well as every summer and autumn in all the large cities of Europe and America, but excite no special comment, unless an epidemic supervenes, or is already rampant, when these otherwise ignored cases are seized upon, collated, and described as foci of the pestilence. It is not the custom *then* to regard such cases as due to a localized generation of the disease, and the fact the *comma bacillus* may be detected is held conclusive evidence, ignoring the well established fact that this microbe is by no means pathognomonic, but present even in conditions of health.

That in the present stage of knowledge it is impossible to explain all the phenomena of cholera distribution by telluric or meteorologic conditions may be allowed, yet neither can such influences be denied. It must be remembered the same difficulties obtain in regard to malaria and kindred diseases, and that one has as substantial claim to this theory of diffusion as the other. And that cholera in its ætiological relations does present marked parallelism to other diseases that are dependent chiefly upon topographical surroundings for propagation is proved by the fact even malaria‡ sometimes breaks loose from its endemic haunts and shows itself in places where it before was totally unknown (Von Hertz).§

It is a matter of common experience that removal from a locality in which cholera exists is a remedy against the spread of the disease, and the East Indian government has for many years acted on this knowledge with regard to its troops and convicts with gratifying success. It is equally a matter of experience that, while it manifests itself with unusual severity in certain localities, in others closely contiguous its ravages are comparatively mild or wholly absent. Often it has been observed in the case of an outbreak on shipboard in port that the shifting to a new anchorage, perhaps only a few hundred yards away, or to the other side of the river or bay, has sufficed to end an epidemic.

An instance in fact may be cited in the visitation of America in 1853-54, when Sarnia, Ontario, and St. Clair, Michigan, suffered severely, while Port Huron, just across the river from the former and twelve miles above the latter, had but three cases, and these, there is every reason to believe, obtained the infection in Canada.

At this period neither of these towns was provided with sewers or any form of drainage other than af-

* "Physiological and Pathological Researches," London, 1888.

* "A Treatise on Asiatic Cholera," London, 1870.

† "Die Verbreitungsart der Cholera in Indien, nebst Atlas," Braunschweig, 1871.

‡ That the parallel between malaria and cholera is much more close than generally imagined is, however, evidenced in that both depend for their phenomena upon disturbances of the vaso-motor system.

The contracted vessels of the skin and the rigors associated with the cold stage in malaria are evidences of hypertrophy and hyperæsthesia of vaso-motor nerves; while increased temperature, flushed surface, full pulse, and the dilated blood vessels accompanying pyrexia, exhibit tissue paralysis, both nervous and muscular. The splenic and hepatic engorgements, and the diarrhœas and dysenteries, that are so frequent sequels of malarial poisoning, are derived from dilated and paralyzed arteries, and, consequently, excessive flow of blood to undilated, enfeebled tissue. In cholera, too, we have paralyzed blood vessels; but there is also another dangerous factor, in a measure specific and dependent upon the former, in that the blood itself is constantly and rapidly being deprived of its serum.

§ Ziemssen's "Cyclopedia of Practical Medicine," New York, 1874.

forded by natural topography, and the fermenting and decaying "sawdust pavements" of the streets of Port Huron, it might be supposed, would naturally tend to foster the epidemic. But the real reason for the immunity doubtless was the dwellings for the most part were confined to a sandy or loamy, porous soil overlying a substratum of blue clay, the latter with a dip of from twenty to thirty feet to the mile, sloping toward the St. Clair River. Sarnia and St. Clair both rest on an outcropping of clay that was baked and seamed by the hot sun of a summer supervening upon a wet spring.

Again, on November 9, 1817, cholera attacked the camp of the East India Company troops, stationed on the borders of Scindia; this cantonment was on the *right* bank of the Sindh or Betwa River; but the ravages were stayed as by magic when the forces were moved over to the *left* bank, a distance of not more than three-eighths of a mile.

It is also interesting in this connection to know that in India, in 1819, the citidal of Jaragurth, situated in a slight depression one thousand feet above the level of the plain, lost many of its inhabitants, while a city near the foot of the mountain, with good natural drainage, entirely escaped attack!

Another peculiarity more or less positive in its evidence is that, while certain districts are exempt during any one epidemic, or series of epidemics, the same may on a subsequent occasion be attacked, though there is always a decided predilection for some localities at all times. It is not uncommon to find the epidemic passing over large tracts of country, with the wind perhaps in its very teeth, and it seldom spreads itself on any systematic or geographic plan, since it may appear simultaneously in regions a thousand miles apart.

Indeed, nothing can be more capricious than the variation in the intensity of the malady in different places and at different times, or at different times in the same places. An imported case may end in a local attack, confined to a single room or single house; even a simultaneous importation of a number of cases at different points may exhaust itself in a number of local (circumscribed) epidemics; while at other times a single case suffices to produce a general epidemic or even a raging pestilence. The history of different epidemics in large cities shows the greatest variety of effect, accordingly as the cholera poison found the conditions for development more or less suitable.

And when the disease is fairly established as an epidemic its spread in a severely infected place is by no means general or in any way uniform. A row of houses, a series of streets or blocks, or perhaps a ward or other section, becomes an epidemic center. Then, again, there are individual room (or several room) epidemics, sometimes with a certain preference for damp cellar lodgings; or individual groups of houses are attacked in one street; often only one side of a thoroughfare is ravaged, or out of a series of blocks, perhaps only one complete square and one or two streets will be visited, while all about in the vicinity there will only be, here and there, an isolated case, or none at all. Here is illustrated the combined effect of importation and of local fixation of cholera germs in the ground or drinking water, in the moisture of the walls, in the damp, heavy, musty air of unventilated rooms, and in the emanations of sewers; while the dissemination is effected by adhesion of the germs to the washing, bedding, vessels, etc.

What the primary factor may be, then, is uncertain, but the fact remains that the production and course of the malady are so greatly under the control of sanitation that neglect of measures, essential to the latter, on the part of individuals and municipal, county and State authorities, as well as the general government, is little (if any) less than criminal.

Even without knowledge of essential cause, we are perfectly familiar with results and effects, and these afford the text upon which to work. We do know, aside from telluric or meteorologic conditions,* that the disease, though not in strict sense contagious during epidemic times, is in considerable degree at least infectious, the poison apparently being constant in the dejections of cholera patients; that this poison may be disseminated at points remote from the ravages of the malady by being carried thither in the intestines of individuals, who perhaps present no evidences of cholera, other than a slight intestinal flux, hence have no idea they are victims, or being made involuntary means of communication; a transient traveler may thus, through a single privy or water closet, infect a whole community.

Niemeyer tells us that in 1848 a detachment of recruits from Stettin, where cholera was raging, went to Magdeburg, two of whom on the night of their arrival fell ill of the malady, and were immediately sent to the military hospital without coming in contact with the inhabitants. Nevertheless, a few days later cholera asserted itself, first in the house where they had sojourned a few brief hours and later along the street on which the dwelling was situated—all from the use of a privy by one of the unfortunates. Again he remarks:† "A small epidemic in Greifswald gave me excellent opportunity for observing the spread of cholera, and in almost every case I could find that the patients had used the privy of affected houses, or had used a privy in common with persons from these houses who had diarrhœa."

F. D. Alexandre tells of a soldier attacked with diarrhœa, who arrived at the village of Haime, from Paris, where cholera was raging, April 4, 1849, and remained three days at his father's house, when he went to the hospital. There was no supposition of cholera in his case, so light was the attack. In the course of ten days seven persons in the household contracted the malady, four of whom died.

Frederick Wm. Goering corroborates with an account of a vagabond, suffering in like manner, who was committed to the workhouse at Dieburg, with the result the epidemic swept through that institution, but nowhere else manifested itself in the town, save in a single instance. The exception was a woman who acted as laundress to the prison.

Also, Prof. Von Pettenkofer relates the case of a man committed to the prison of Ebrach, from Munich, during the existence of cholera at the Bavarian capital, and who suffered from intestinal flux. His diarrhœa persisted, though its nature was not recognized, and he was sent to prison hospital. Immediately the epidemic developed within the institution, the first victim being a female prisoner who had washed the clothing soiled with the diarrhœal discharges of the Munich convict.

Of the pernicious effects of general or common latrines may be cited the fact that, during epidemics in America, the soldiers of the United States army and of the marine corps suffered more severely than any other relative number of people. The closets or privies in connection with barracks are usually in a foul state, and in most instances are merely open trenches, with but a rude shelter to protect from the weather.

Since it has been shown that the malady is only transferred to healthy persons—persons possessing no special or abnormal receptivity—through the dejections of those afflicted with the disease, the previously enigmatical and apparently contradictory observations concerning the spread of an epidemic are satisfactorily explained. Further, that it spreads more rapidly than formerly is accounted for by the fact the facilities for travel and communication are greatly increased; and it is little wonder the generally traveled routes exhibit the greatest ravages, or that extension is against wind, or by long leaps, with occasional retrocessions, while places intervening escape—traveling cholera victims infect only those places where they leave their dejections. Again, if the cholera germs were contained only in the dejections of those who suffer from the severest form of the disease, as they cannot travel, long springs of cholera epidemics could only occur through spontaneous generation, or when persons infected with the poison traveled during the period of incubation, and the disease in them did not assert itself *en route*. But besides such, numerous examples prove that persons suffering from simple choleraic diarrhœa (as in the Magdeburg cases cited by Niemeyer), and who at no time are very ill, carry with them the fatal germs, and, by infecting a single water closet or outhouse, may start an epidemic *de novo*, as it were.

Lebert believes even a healthy person may carry the germs from locality to locality, and yet suffer no inconvenience, *i. e.*, he may escape the malady altogether. He calls attention to the fact one seizure also renders individuals in some degree personally immune, though their aptitude for carrying the infection is in no way lost, provided they have been exposed to its influence. While he declares his doubt whether the cause is an organic poison or living organism, he is inclined to accept the mycetic theory, which, as he remarks, "explains without strained effort why it is that fluids, and especially stagnant fluids, containing more or less organic nutritious matter, are chief vehicles of the cholera germs, as they are of all protomycetic forms. It is on this account that the water of the soil, the drinking water, and every fluid play so highly important a role in the diffusion of the disease; and yet neither the ground water nor the drinking water theories can ever prevail in sole sovereignty as causes of the disease, since such are not necessary for the development of the germs, but only become so when they can furnish these germs with proper nutritious matter, when other favorable conditions of growth are presented, and when more especially the way of communication with the human organism is open. The germs of cholera may be spread without ground or drinking water just as easily as with them, through the air, by becoming attached to solid bodies, etc. . . . True, cholera finds in drinking water also a very frequent and most potent medium of dissemination, as it may be impregnated with the poison (from water of the soil by filtration from privies and sewers), which may then flourish in further development. Still, drinking water alone cannot be considered as the exclusive or necessary means of dissemination. Overflowing or badly cemented drainage or sewer pipes, for instance, conveying infectious matter, may carry their foul contents directly into the ground walls of cellars and dwellings, and swiftly develop destruction among the inhabitants."

It is probable, however, the dejections do not, when first expelled, contain the cholera germs in the stage of development necessary to infection, but that they become strictly aggressive only after having undergone fermentation, which result is furthered by admixture with decomposing animal substances, and this is why the midden privy is always a greater source of danger than the modern closet. This theory is supported by numerous facts.

Dr. O. D. Norton, a veteran practitioner of Cincinnati, who had extended experience with cholera in the epidemic of 1849, remarks, regarding experiments with *fresh* alvine excretions of choleraic ("rice water") character, that he and a confrere fed such by *bucketsful* to numerous chickens and pigs, but induced in them no evidences of the disease; on the contrary, these creatures seemed "to grow fatter" thereon.*

The observations of C. Von Thiersch show that while recent dejections are not dangerous to animals, feeding the same with *old* excreta of the same sort invariably induces the malady.†

Further, experience shows that physicians passing from bedside to bedside are comparatively immune. Niemeyer says his experience in cholera epidemics, wherein he wrapped patients in blankets and often held them in his arms for some time, made him a "decided anti-contagonist;" that those who washed the body and bed linen after they have lain some time are more apt to be infected than those who directly care for the patient, even to removing the dejecta.

Again, Lebert says: "I have noticed in all epidemics, and have seen it mentioned in the writings of many authors, that practicing physicians, even hospital physicians, are seldom attacked with cholera."

In Cairo, Egypt, in 1831, of one hundred servants employed as rubbers or *masseurs* of cholera patients, not one was ever attacked; of eighty rubbers at the hospital at Mansurah and sixty at Damietta, all escaped save one. None of the physicians or nurses of the cholera service at Constantinople in 1855-56, and Oran in 1861, ever suffered from any form of the disease.

Washerwomen, whenever they washed linen soiled with cholera dejections, without any precautions, are attacked in all places in no small numbers.* In Branson, in the Canton of Valais, Switzerland, in 1867, one of the sisters of charity nursed, with the greatest self-sacrifice, all the cholera patients in very filthy chambers, and yet remained healthy, but at the close of the epidemic "her sympathy prompted her to assist in washing up the soiled linen, when she was attacked with the disease and died. It was from a washerwoman who died after washing the clothes of a cholera fugitive that the epidemic developed later in Zurich, 1867" (Lebert).

Very numerous facts might be cited to demonstrate that cholera may be communicated and carried from place to place by clothing or other material soiled by cholera dejections; the observations of Etienne Moulin, Gaston Pellissier, Jas. Simpson, Jules Bucquoy, J. M. and D. D. Cunningham, Max von Pettenkofer, Antoine Fauvel, Augusto Guastella, and others, are most definite. Guastella remarks:† "There were persons living in places sheltered from the epidemic who, after washing linen soiled with the dejections of cholera, carried the disease afar."

Fauvel adds other facts‡ showing that camping places where an epidemic has occurred, hospital wards, sick chambers, ships and cars carrying cholera patients, etc., may preserve for some time, under certain circumstances, the power of transmitting the disease; nevertheless, such examples are comparatively rare. To transmit cholera by clothing, he considers, demands certain conditions, viz.: "To transport it a short distance requires certain contact with objects in connection with the patients, especially those soiled by vomit and rectal discharges; to transport long distances, the objects previously exposed to contact must be confined to close quarters where the fresh air is not renewed, and where sunlight does not enter. There are few examples of objects freely ventilated carrying the disease for any long time or long distance; while there are many cases to prove transmission may easily occur where soiled effects have been closely packed for several months."

As to the influence of dead bodies in disseminating infection directly—*i. e.*, by handling—Lebert expresses himself as doubting it very much. "We occupied ourselves almost daily in Paris, in 1849, my friends and myself, with investigations into the pathological anatomy of cholera. In Zurich, in 1855, I made all the post-mortem examinations, with my assistant, Dr. Wegelin, and neither of us, and no one of our dead-room attendants, were attacked with the disease. I consider it, therefore, merely an accident when a body carrier falls sick. I believe, indeed, that animal putrefaction rather diminishes the capacity for infection, and that the bacteria of decomposition destroy the germs of cholera."

Hugo Wilhelm von Ziemssen § lays especial stress upon the fact "it is more dangerous for the persons in a house if the evacuations are emptied into a privy filled with excrement, into a cesspool, or thrown on a dunghill, as in such places the germs seem to find circumstances most favorable to their development and increase."

A. Von Hirsch ‖ insists marshy and malarial regions are especially favorable to the dissemination of cholera in that they furnish nourishment for the germs favoring their multiplication; also because the soil in such localities is eminently fitted to transmit, by soaking and slow filtering, cesspool fluids and sewage waste, carrying into cellars and basements; that thus the privy of a neighbor may be more dangerous than one's own, especially if in close proximity to the residence of the latter.

From observations made during the last three epidemics in France, Dr. Hippolyte Mireur concludes cholera is not transmitted directly from the ill to the well by contact or through the respiratory passages; that the products emanating from cholera patients—the dejections and vomited matters—alone contain the germs, which are not immediately transmitted by themselves, but when placed under favoring conditions give rise to an infectious principle; that clothing and merchandise, such as skins, hides, rags, etc., much more than individuals, are the agents for the transportation of this principle.¶

Prof. Von Pettenkofer discovered that porosity of the soil, by enabling the contents of privies and cesspools containing the cholera germs to freely permeate and soak the ground for some distance around, and poison wells and sewers, favors the rapid extension of the disease, while the opposite quality to some extent inhibits dissemination; and the same author was the

* The arguments for and against the contagious nature of cholera are many and varied, and some of the positive are the result of misunderstanding and misapprehension. Thus, certain German writers are frequently quoted as contagionists, when in fact more careful perusal of their writings show they are only infectionists; this error arises from the fact there is but one term (*Ansteckung*) in the German language to express both conditions.

Surgeon Lieut. Colonel J. M. Cunningham, Health Commissioner of India, who for years has studied cholera where it is endemic, emphatically declares it is not contagious. Dr. Edward Goodeve, who likewise has had extended experience in various portions of the Orient, insists the malady "does not spread from the sick to the well by any rapidly acting emanation." Surgeon General Chas. Hunter, in his report upon the epidemic in Egypt in 1884, is equally assured of its non-contagious nature. Many others have noted that patients ill with the disease may be attended, washed, lifted, etc., with very little risk, and that the discharges from stomach and bowels are the chief if not the only sources of danger. Herman Lebert pointedly remarks (Ziemssen's "Cyclopedia of the Practice of Medicine," vol. i.): "Cholera can be spread only by contagion, that is, by germs which are carried from a diseased to a healthy person; but these germs infect only comparatively rarely by intercourse or contact with cholera patients, since they possess relatively but little vitality in the air of the sick room, and are present mostly in inconsiderable quantity. On the other hand, a certain number of the germs and a given vitality are necessary for the propagation of the disease, and these conditions are better met in fluids than in the air; hence contagion is more frequent when the germs are communicated through a fluid than when transmitted through the air."

Thus it seems, while Lebert apparently pronounces for *contagion*, he really means what in English would be *infection*. Felix von Niemeyer ("Text Book of Practical Medicine," vol. ii.) expresses himself in like manner, and subsequently adds he is a non-contagionist, later explaining his position, making him in fact an *infectionist*.

† "Text Book of Practical Medicine," vol. ii., New York, 1884.

* Cincinnati Lancet-Clinic, vol. xxiv., Sept. 24, 1892.

† "Meine Cholera-Infectionsversuche vom Jahre 1854 und die des Herrn Dr. B. J. Stokvis vom Jahre 1866." Munich, 1867.

* The frequency with which washerwomen fall ill with the disease from contact with infected linen has often been mentioned, but there are also examples where cholera has been spread by rags and other objects. The same is true in still higher degree of unclean bedding. C. Von Zehnder ascribes the origin of two cholera centers in the Zurich epidemic of 1867 to an accumulation of bedding, mattresses, pillows, etc., that had been used on the beds of cholera patients, and afterward piled up, before being carried off for disinfection, in the neighborhood of the houses affected.

† "D'igiene e medicina navale ad uso della marina merchantile." Trieste, 1861.

‡ "Le Cholera; etiologie et prophylaxie." Paris, 1868.

§ "Die Choleraepidemie vom Jahre 1867." Greifswald, 1870.

‖ "Ruckblick auf die neuere Choleraliteratur." Schmidt's Jahrbucher, Bd. lxxxviii.

¶ "Etude historique et pratique sur la prophylaxie et le traitement du cholera," etc. Paris, 1884.

first to demonstrate the "manifest fitness of any locality for the disease depends on excrement, containing the germs, permeating the soil and exposed to circumstances favorable to decomposition."

Next to soaking of the soil is the danger from gutters and drains which may carry the infection from house to house; and it is well known that a soil pipe, or untrapped rain gutter, has carried the disease into an uninfected dwelling through a window of the latter being contiguous to, and at higher elevation than, the upper end of the latter.

Neither can there be any doubt as to the role played by foul drinking water in cholera dissemination. Mr. J. Snow * established the connection of the fearful local epidemic in Broad Street, St. James' Parish, London, in 1854, with an infected well; its ravages ceased when this supply of water was shut off from the public.

John Simon† declares in the portion of London supplied with river water drawn from the stream after it had received the contents of a large number of sewers, so that it had 46 grains of solid constituents to the gallon, the number who succumbed to the malady was 13 out of every 1,000, while in other situations, under precisely parallel circumstances and surroundings, save the water supply contained but 13 grains of solids to the gallon, the death rate was only 3·7 per 1,000. Edward Frankland,‡ speaking of the same city and the relation of water supply to cholera, says:

"On August 18, 1866, a family removed from London to Margate; on the 26th there was a storm with heavy fall of rain, and the water had an unusual odor and taste. On the 27th, four persons were attacked with cholera, and on the following day still more, the most of whom died. The water in the well at the end of the garden furnished, in 100,000 parts, 93·4 of solid matters, of which 7·36 parts were of organic or volatile nature. The cesspool adjoining the garden had clearly poured its contents into the well after the overflow caused by the rain, and this had caused the fatal contamination, for an analysis made September 18 showed 82·75 solids (in 100,000), of which but 1·13 parts were of organic or volatile nature. It was proved that all who were attacked had drank from the well. A similar occurrence was established by Dr. Lancaster, of Epping Forest."

The same author declares the inhabitants of London who used Thames water from Kew, above the city, showed a mortality from cholera of but 8 in 10,000; those who used the water from Hammersmith, 17 in 10,000; from Battersea to Waterloo Bridge—that is water contaminated by the sewage of the city—163 in 10,000. In 1854 only the half of a district was supplied from Teddington Loch, and the mortality therein was 87 in 10,000; but in 1866, all the water in the Loch having been drawn off, the mortality was less than one-tenth of that in 1854. Again, in 1866, the cholera was very severe in the East End, which was supplied by the East London Water Company from Oldford on the River Lee, the reservoir being little better than an open excrement and sewer receptacle, even filtration being neglected: the result was the mortality in this portion of the city was from 63 to 112 per 10,000, while the balance of London, with a pure water supply, exhibited a death rate of only 2 to 12 per 10,000.

Manchester suffered terribly from cholera in 1832 and 1849, when the water supply was very impure; but in 1854 and 1866, the water being derived from the interior of Derbyshire through an aqueduct, there were very few cases, and these only of a sporadic character.

Dr. W. Schiefferdecker, too, mentions a fact worthy of note concerning the six great cholera epidemics that ravaged Koenigsberg, Prussia, from 1831 to 1866, in which more than 2,500 people succumbed out of nearly 6,000 attacked.§ The inhabitants of those portions of the city supplied with drinking water from the river Pregel, and from wells, were those that suffered most, while those supplied by a system of water works, from the so-called "upper tank," in which the water was exceedingly pure, suffered much less severely; the Pregel and wells were fed with ground water and sewage.

Dr. J. Graetzer also describes an instance occurring in Breslau during the epidemic of 1867,‖ in which the walls of a badly constructed privy attached to a newly built and well arranged house rendered the water in an adjacent well impure; besides the privy vault was not regularly emptied, and its contents overflowed into an unwalled excavation in the neighborhood of a large accumulation on ground water. The consequence of this contamination, which affected the drinking water, was that in the beginning of the epidemic no less than twelve of the inhabitants of the house were attacked, eleven of whom died; also other persons in the vicinity, who obtained water from the same well, were seized. In this instance it was proved the cholera poison first entered the privy; then passed into the ground water, then into the drinking water, and so on into the digestive organs of the unfortunates.

Again, when cholera is once introduced, it sometimes happens only those are attacked in the house where the first infection is received, or who visit the same closet; and in some instances the malady has been restricted solely to house epidemics—further illustration of the care that should be exercised in the way of sanitation.

Niemeyer believes the poison is rarely taken into the system in the drinking water, but in the main enters the economy during the act of respiration, and lodging in nose, mouth or throat, is swallowed with the saliva. "Using infected privies is so dangerous, because they are the favorite lurking places of cholera germs, and the gases arising always contain dust-like particles." The poison passes from the closet to the dwelling, and A. Biermer insists the latter are "more liable than individuals to infect."

If now there is any justice in the belief of Lebert, Hirsch *et al.* that the cholera germ lies within a spore,¶ it is more than probable the ripening of such in the fæces after evacuation is the real source of infection; or that the product of the ripened spore, on being returned to an economy, further develops, producing perhaps certain alkaloids that, in turn, taken up by the absorbents, induce violent toxic symptoms—symptoms that, made manifest through the nervous system, constitute the phenomena of the disease. Dr. Thomas King Chambers remarks:* "There is every reason to believe the chief exciting cause of the disease is a poison generated by decomposing organic matter and received into the body from without. To judge by its effects, it seems widely diffused through the air, especially in the neighborhood of its origin—in the air of privies, cesspools, sewers, putrid marshes, and crowded human habitations. One is perhaps tempted to ask how it is, if the poison is spread so broadcast, that everybody does not get poisoned: but it must be remembered two things are necessary to poisoning, viz.: Not only a poison, but a person in condition to be poisoned; and in point of fact, the *latter* is the more important element in the transaction."

Thus the weight of evidence goes to show cholera epidemics, for existence and dissemination, demand three prime factors, viz.:

First. Conditions of soil, atmosphere, etc. (general surroundings), favorable to the nourishment of the germ or germs, which would otherwise speedily lose the power of infecting.

Second. Conditions in each human subject individually favoring receptivity.

Third. Direct infection *per se.*

And regarding the last, it is believed the principal, if not the only way of insuring infection, is through the medium of the intestinal canal and its absorbents.

That the germs are ordinarily carried but a short distance through or by the air.

That the great danger lies with the alvine evacuations and vomited matters, but only after fermentation has been set up therein.

That contamination of the water supply and of food by cholera discharges is ever a grave factor.

And finally, that linen, cotton, or woolen fabrics, soiled by cholera excreta, if excluded from air and sunlight, serve to keep alive the germs of the disease for an indefinite period. The history of the bark Swanton, on which cholera did not appear until she had been at sea for twenty-seven days, when clothing was unpacked by the passengers, also of the ship New York, on which the disease did not manifest itself until she was sixteen days out from her port of departure, and then under the same circumstances as on board the Swanton, both evidence the truth of this statement.

650 Congress St. E., Detroit, Michigan.

* "Cholera and the Water Supply in the South District of London in 1854." London, 1856.

† "Report on the Last Two Cholera Epidemics as Affected by the Consumption of Impure Water." London, 1856.

‡ "The Water Supply of London and the Cholera." *Quarterly Journal of Science*, 1867.

§ "Die Choleraepidemie vom Jahre 1871 in Koenigsberg." Koenigsberg, 1873.

‖ "Die Breslauercholera-Epidemie." Breslau, 1873.

¶ The question of a spore is an interesting one from a certain standpoint, since the majority of observers of and believers in deny such to the comma bacillus; yet Huppe, of Prague, declares this germ does possess "a fructification propensity by virtue of an arthrosporulation," which he personally observed.

* "The Renewal of Life; Lectures, Chiefly Clinical." London, 1864.

THE BAOBAB.

THE baobab, Ethiopian sour gourd, or monkey bread (*Adansonia digitata*), of the natural family Bombaceæ, is a native of many parts of Africa. It has been found in Senegal and Abyssinia, as well as in the west coast, extending to Angola, and thence across the country to Lake N'gami. It is cultivated in many of the warm parts of the world. It has been called the "Tree of a Thousand Years," and Humboldt speaks of it as "the oldest organic monument of our planet." Adanson, whose name the genus bears, and who traveled in Senegal in 1794, has given an account of this tree. He made a calculation to show that a certain specimen, 30 ft. in diameter, must have been 5,150 years old! He saw two trees, from 5 to 6 ft. in diameter, on the back of which were cut, to a considerable depth, a number of European names, among which one was dated in the fourteenth and another in the fifteenth century. In 1555, the same trees were seen by Therat, another French traveler, who mentions them in the account of his voyage.

Livingstone says of the tree: "I would back a true mowana (the name given to it in the neighborhood of Lake N'gami) against a dozen floods, provided you do not boil it in salt water; but I cannot believe that any of those now alive had a chance of being subjected to the experiment of even the Noachian deluge."

The baobab was formerly considered as the largest tree in the world, but it must now give way to the "big tree" of California (*Sequoia gigantea*). Its height is from 40 to 70 ft., and not at all in proportion to the size of its trunk, which sometimes attains the great diameter of 30 ft. It soon divides into branches of great size, which bear a dense mass of deciduous leaves, somewhat like those of the horse chestnut. The flowers are large, white, solitary, and pendent on long stalks, and when expanded are about 6 in. across.

The fruit (Fig. 2) is an oblong woody capsule, covered with a short down, and from 8 in. to 1½ ft. long, and in appearance somewhat like a gourd. Internally it is divided into 8 or 10 cells, each of which is filled with a pulpy substance in which the seeds are embedded.

The bark of the baobab furnishes a fiber which is made into ropes, and in Senegal woven into cloth. The fiber is so strong as to have given rise to a common saying in Bengal: "As secure as an elephant bound with a baobab rope." The wood is soft, and subject to the attacks of a fungus which destroys its

FIG. 2.—FRUIT OF THE BAOBAB.

life and renders it easy to hollow out the part affected. This is done by the negroes, and within these hollows they suspend the dead bodies of those who are refused the honor of burial. There the bodies become mummies, perfectly dry and well preserved, without any further preparation or embalmment. Livingstone speaks of a hollow trunk within which from 20 to 30 men could lie down with ease.

The leaves, dried and pounded, constitute *lalo*, which the Africans mix with their soups, sauces, etc., not as a relish, but to diminish excessive perspiration and keep the blood in a healthy state.

The pulp of the fruit is slightly acid, agreeable, and often eaten; and the juice expressed from it constitutes a drink which is valued as a specific in putrid and pestilential fevers. Owing to this circumstance, it forms an article of commerce.

The ashes of the fruit and bark, boiled in rancid palm oil, are used as a soap by the negroes.

The only other species of the genus is *Adansonia Gregorii*, which is a native of the sandy plains of Northern Australia, and is known as sour gourd and cream of tartar tree. It differs chiefly from the foregoing species in its smaller fruit, with a shorter foot stalk. The largest tree seen in Gregory's expedition was 85 ft. in girth at 2 ft. from the ground. The pulp of its fruit has an agreeable acid taste, like that of

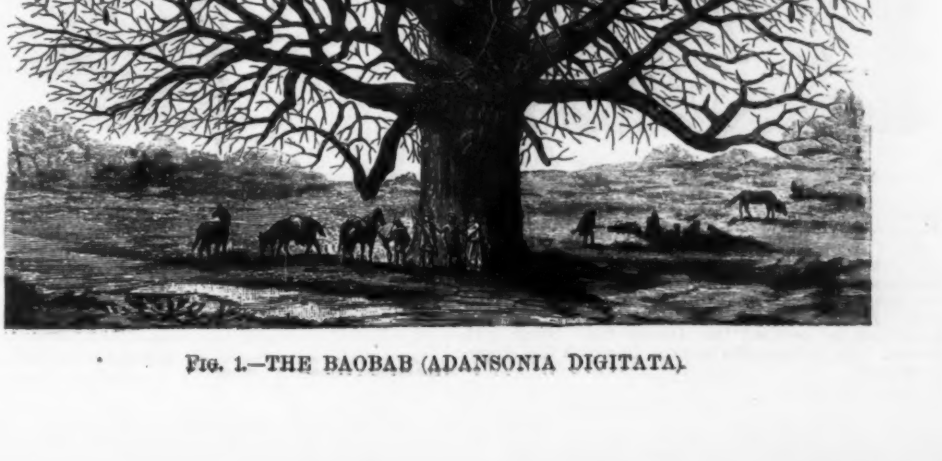


FIG. 1.—THE BAOBAB (ADANSONIA DIGITATA).

cream of tartar, and is peculiarly refreshing in the sultry climates where the tree is found. It consists of saccharine matter, gum, starch, and malic acid.

HYACINTHS IN MOSS.

The accompanying cut represents a hyacinth growing in a ball of moss. In this case a beet root had been inserted in the lower part of the ball, with the head downward, the leaves of which are to be seen curling up round the ball. The moss merely requires to be

HYACINTH GROWING IN A BALL OF MOSS, ETC.

kept damp, and the system is a pleasing change to growing them in water.—*The Gardeners' Chronicle.*

A SCOTCH MONEY BOX.

The accompanying figure represents a novel money box which a contributor to *La Nature* came across in Edinburgh. The box (1), which is of wood, is provided at its upper part with a drawer. In the normal position of the box, the drawer can be opened, but not withdrawn. If a coin be placed in the drawer and the latter be closed and then reopened, the coin will have disappeared, although the drawer apparently contains no aperture.

The ingenious mechanism of the box is arranged as follows: The body of the drawer consists of a thick piece of wood containing a circular cavity. The bottom is hinged, and, when the drawer is pulled out, applies itself against the body of the latter, and drops again when it is closed. In fact, it abuts against the lower edge of the cavity, and rises gently without the least resistance being felt. The travel of the drawer is limited by a nail movable in a cavity closed by a plug. If it be desired to empty the box, it suffices to turn it

A SCOTCH MONEY BOX.

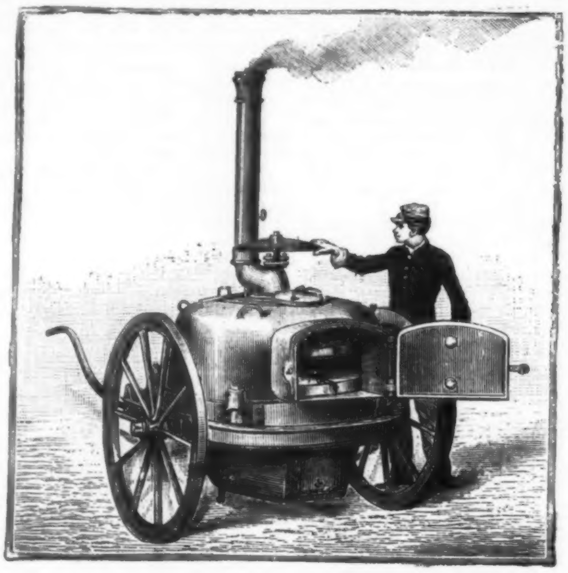
upside down, when the nail will re-enter and the drawer can be taken out.

No. 1 shows the box open. The only sign of the movable bottom is the extremity of its axis, marked in the figure by a small dot at the lower part of the drawer, the sides of which guide it perfectly. In No. 2 the box is inverted, and it will be seen that there is no projection to prevent the drawer from being withdrawn. No. 3 shows the manner in which the drawer is emptied.

OVEN ON WHEELS FOR ARMY USE.

We represent herewith the new Chappée oven now in use in a large number of bodies of troops. This ingenious apparatus consists essentially of a metallic body containing two grates placed one above the other, mounted upon the same shaft, and capable of being revolved through the maneuvering of a hand wheel placed on a level with a man's shoulder. Each of the revolving grates carries eight vessels of appropriate form arranged as shown in the figure.

Beneath the metallic body thus arranged there is a firebox, in which the fuel used may be either wood or coal, or coke even. The whole is mounted upon



PORTABLE OVEN FOR ARMY USE.

wheels, so that it may be easily moved about from one place to another.

The process of baking meats is as follows: The eight vessels of each grate having been filled with the pieces of meat that they are to contain, the cook puts them successively into the oven, and in the place assigned to each by revolving the grates past the mouth of the oven through the aid of the handwheel. After the door of the oven has been closed the baking requires a time that may vary from forty-five to sixty minutes, according to the nature of the meat and the thickness of the pieces. During the operation the cook must keep his hand constantly on the handwheel and cause the grate shaft to revolve methodically, in order to equalize the action of the fire. He may properly modify such action, moreover, by regulating the chimney damper. At all events, it is indispensable that the heat shall be kept regular until the meat is baked.

The oven may likewise be used for baking bread or any other kind of food. It is capable of being dismounted and of being mounted again without the aid of bolts. Bodies of troops on station can remove it from its wheels and give it a stationary position by placing it upon four small columns. From a series of experiments made at Tours, it has been found that in ten months' use, nothing being paid during this time to city bakers, a company can earn the purchase price of its oven.—*La Nature.*

TO BLOW THREE SOAP BUBBLES ONE WITHIN ANOTHER.

Three soap bubbles may be blown one within another as follows: Pour a little saponaceous liquid* into a saucer, in which place a cork upright. Afterward, take a small China doll and fix its feet to a silver dollar by means of sealing wax. Then, with the same substance, fix a small disk of cardboard about half an inch in diameter to its head. This done, place the coin that carries the doll upon the cork, after wetting the edges of the saucer, the cork, the doll and the coin with the liquid. Place the saucer upon a goblet, so the spectators may get a better view of the experiment.

Dip the bell of a child's trumpet into the liquid contained in the saucer, and then placing it above the doll, with the tube vertical, blow the first bubble. This will not burst in contact with the objects placed in the saucer, since they are wet with the same liquid as that of which it is formed, but will descend along the doll to the coin, then along the cork to the saucer, and will attach itself to the rim of the latter. Stop blowing after it has attained a diameter of 6 or 8 inches. So much for the first bubble, the external one. Now take a copper tube (say a hollow curtain rod), wet it for nearly its entire length in the bottle of liquid, and boldly introduce its extremity into the bubble, which will not burst. Take up some of the liquid from the saucer and blow a bubble, which will descend along the doll. Stop after it has attached itself to the circumference of the coin and has reached a diameter of 3 inches. The doll will thus appear as if inclosed in a double bell glass. Carefully withdraw the tube, wet it in the bottle of liquid, pass its extremity through the two bubbles already formed, and blow a very small bubble of about one inch in diameter, which should rest upon the disk, if the apparatus is perfectly perpendicular. The blowing of this third bubble is a little more delicate operation. We dedicate it to amateurs, but anybody may succeed in blowing the two first bubbles.—*Le Chercheur.*

THREE SOAP BUBBLES ONE WITHIN ANOTHER.

* A solution of one part castile soap in 40 of water, to which is added one third its volume of glycerine.

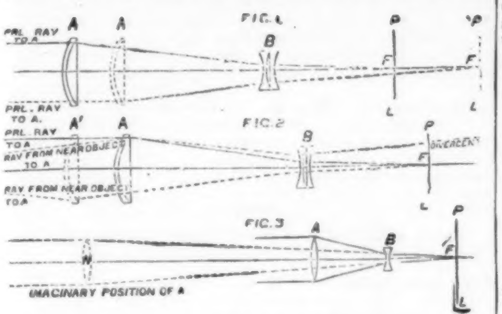
PHOTOGRAPHING MONT BLANC FORTY MILES OFF.

One of the attractions in the exhibition of the Photographic Society in London is a photograph by Mr. Boissonnas, representing Mont Blanc on a large scale as photographed by him at Geneva, forty miles away. A clear day had to be selected for the work, says *The Engineer*, and orthochromatic plates used. The chief agent in getting the large scale was a new lens by Mr. Dallmeyer, made somewhat upon the opera glass principle, whereby he obtains a large image combined with an exceptionally short distance between the lens and the plate. The mount of the lens is rather large, something like a small coffee canister; but it is constructed of aluminum to avoid excessive weight, and the lens has the advantage of giving telescopic effects in conjunction with cameras of moderate extension.

An optical peculiarity of the lens is that the nodal point of the rays is in front of the front element of the combination. For military and naval purposes the lens is likely to be useful; a Liverpool photographer in the past generation first drew the attention of the war office to the value of lenses for such work, by photographing a fort from the opposite side of the Mersey by means of a telescope objective. In the photographing of such distant objects, however, one is much more at the mercy of the state of the weather than when photographing anything close at hand, the slightest fog or mist being fatal in long distance views for scientific purposes. For artistic purposes cloud and mist are sometimes advantageous. Mr. Dallmeyer has

favored us with the following particulars relating to the construction of the lens :

Fig. 1.—The upper black ray meets the lens, A, parallel to the axis, and, by a proper adjustment between A and B, comes to focus at F, upon the plate, PL. If PL be removed farther from the lens, B, to take the position, P'L', the lens, A, will have to be moved slightly nearer to B, and take the position, A'. Fig. 2.—On the upper side of the axis a parallel ray to A finds its focus as in the dark line on the plate at F. If, however, some ray from a near object falls upon the lens, A, in the direction of the dotted line, after passing through the lens, B, it is found divergent, and



no positive focus is obtainable. Fig. 3 represents a beam of rays passing through the two component elements, A and B, coming to focus upon the plate, PL. To estimate the rapidity it is necessary to consider the full aperture placed at the principal focal plane passing through the nodal point at N. A is thus made to take up an imaginary position. The position of the nodal changes for different positions of the plate PL.

THE MANUFACTURE OF LIQUORS AND PRESERVES.*

By J. DE BREVANS, Chief Chemist of the Municipal Laboratory of Paris.

CHAPTER II. (*Continued.*)

SECTION IV.—ALCOHOLIC TINCTURES.

UNDER the name of tinctures are included substances which are obtained by the maceration of aromatic plants in alcohol. They are of two kinds—true alcoholic tinctures, prepared from the dry materials, and spirits (Fr. *alcoolatures*), prepared from fresh materials.

Tinctures are divided into two classes, simple and compound.

Maceration is accomplished by leaving the materials for a greater or less time in contact with the solvent by means of digestors or extractors (Fig. 36). The plants

FIG. 36.—DIGESTOR OR EXTRACTOR.

are placed in the cylinder of digestion, a quantity of alcohol is introduced and the apparatus is heated. The alcohol distilled is condensed in the neck of the still and is returned and the process is repeated continuously. By this operation the alcohol is constantly brought into contact with the materials until it has dissolved as much as possible of the principles of the plant.

Tincture of Absinthe.
Teinture d'Absinthe.

Dry leaves and tops of absinthe (*small*) .... 260 grm.
Alcohol (85°) .... 1 l.

Macerate for 14 days. Agitate daily and filter.

Tincture of Aloes.
Teinture d'Aloès.

Cape aloes .... 200 grm.
Alcohol (60°) .... 1 l.

Macerate for 8 hours and filter.

Tincture Bitter Almonds.
Teinture d'Amandes Amères.

Shells of bitter almonds .... 500 grm.
Alcohol (85°) .... 1 l.

Pile the shells up and macerate for a month at least in alcohol, agitating daily, and filter.

* Continued from page 14177, SUPPLEMENT No. 887.

Tincture of Ambergris.
Teinture d'Ambre.

Gray ambergris .... 16 grm.
Alcohol (85°) .... 1 l.

Macerate for 14 days with gentle heat (25 to 30° C.) and agitate from time to time.

Tincture of Angelica.
Teinture d'Angélique.

Roots of angelica, crushed .... 200 grm.
Alcohol (85°) .... 50 c. c.

Macerate at 25° C. or thereabout and decant the product. Macerate again for five days and repeat with a half liter of 85 per cent. alcohol. Extract tincture with the aid of pressure, unite the two parts and filter.

Tincture of Anise.
Teinture d'Anis.

Green anise crushed .... 250 grm.
Alcohol (85°) .... 1 l.

Macerate for 10 days and filter.

Tincture of Benzoin.
Teinture de Benjoin.

Benzoin in tears, pulverized .... 125 grm.
Alcohol (85°) .... 1 l.

Same method of preparation as that used in making tincture of ambergris.

Tinctures of tolu, storax and cachou are prepared in the same manner.

Tincture of Cinnamon.
Teinture de Cannelle.

Crushed cinnamon .... 100 grm.
Alcohol (85°) .... 1 l.

Macerate the cinnamon in the alcohol for eight days at a temperature of 25 to 30°.

In the same manner are prepared the tincture of cardamom, cascarilla, coriander, mace, musk, etc.

Tincture of Curaçao.
Teinture de Curaçao.

Peel of curaçao (of Holland) .... 500 grm.
Alcohol (85°) .... 1 l.

Macerate, stir daily and filter.

Tincture of Galangal.
Teinture de Galanga.

Bruised roots of galangal .... 750 grm.
Alcohol (50°) .... 1 l.

Macerate after 14 days, filter.

Tincture of Hyssop.
Teinture d'Hysope.

Dried flowering tops of hyssop .... 250 grm.
Alcohol (85°) .... 1 l.

Macerate in the alcohol for 14 days, shaking frequently, then filter.

Tincture of Orris.
Teinture d'Iris.

Florentine orris pulverized .... 125 grm.
Alcohol (85°) .... 1 l.

Macerate for 14 days, then filter.

Tincture of Laurel.
Teinture de Laurier.

Leaves of laurel, dry and cut fine .... 125 grm.
Alcohol (50°) .... 1 l.

Macerate for 14 days, filter.

Tincture of Balm.
Teinture de Mélisse.

Dried leaves of the yellow balm .... 250 grm.
Alcohol (85°) .... 1 l.

Macerate for 10 days and agitate, daily filter.

Tincture of Musk.
Teinture de Musc.

Tonkin musk .... 8 grm.
Alcohol (85°) .... 1 l.

Macerate 10 days, shaking frequently, filter.

Tincture of Vanilla.
Teinture de Vanille.

Vanilla cut fine .... 15 grm.
Alcohol (85°) .... 1 l.

Macerate for 14 days, filter, or proceed as follows :

Mexican vanilla .... 15 grm.
Sugar .... 500 grm.

Triturate the vanilla, cut in fine pieces, with the sugar. Heat the mixture on a water bath with 1 l. of alcohol. Let it cool and filter.

Compound Tinctures.

Preparations of this kind are seldom prepared by liquor manufacturers, as it is easier to mix the simple tinctures, but the product is not as good.

Compound Tincture of Absinthe.
Teinture d'Absinthe Composée.

Absinthe (large) dry .... 60 grm.
Absinthe (small) dry .... 60 grm.
Cloves .... 6 grm.
Sugar .... 30 grm.
Alcohol (60°) .... 1 l.

Bruise the cloves and the herbs. Macerate for 8 hours and filter.

Compound Tincture of Cinnamon.
Teinture de Cannelle Composée.

Cinnamon .... 30 grm.
Cardamom .... 15 grm.
Ginger .... 10 grm.
Pepper .... 10 grm.
Alcohol (60°) .... 5 l. 25 c. c.

Macerate the contused materials for 8 days in alcohol, press and filter.

SECTION V.—SPIRITS.

Under the name of spirits our author includes tinctures prepared from the fresh plants. The general method of preparation is as follows : The contused materials are saturated with 90° alcohol. Macerate for 8 days, after which decant the liquid. Filtration is necessary.

Spirit of Angelica.
Alcoolature d'Angélique.

Fresh angelica roots, stems .... 350 grm.
Alcohol (85°) .... 2 l.

Cut the plant up fine, macerate for 6 days with a little alcohol. Pass through fine linen, press the residue lightly with the remainder of the alcohol and allow it to stand for five or six days. Unite the two infusions and filter.

Spirit of Walnut Shells.
Alcoolature de Brou de Noix.

Nuts, not quite ripe .... 1 k.
Alcohol (85°) .... 1 l. 25 c. c.

Detach the nuts and pile up with care and allow them to blacken for twenty-four hours. Then macerate in alcohol for two months. Express and filter.

Spirit of Currants.
Alcoolature de Cassis.

Currants ripe and picked from the bunch .... 12 k.
Alcohol .... 12 l.

Macerate for 15 days, draw off 4 l. (first infusion), filter. Treat the residue with 4 l. of alcohol (85°), agitate and mix. At the end of 15 days of maceration, draw off anew 4 l. (second infusion) and filter. Add to the remainder 4 l. of alcohol (85°), mix and macerate for 15 days. Draw off all the liquid which constitutes the third infusion and filter. The residue, after pressing, constitutes the fourth infusion.

Spirit of Lemon.
Alcoolature de Citron.

Fresh lemon skins .... 500 grm.
Alcohol (85°) .... 1 l.

Macerate for eight days and filter.

Spirit of Strawberries.

Ripe strawberries .... 1 k.
Alcohol (85°) .... 1 l.

Macerate for 15 days and filter. In the same manner are prepared spirit of raspberries, pineapple, etc.

SECTION VI.—DISTILLED WATERS.

Distilled waters, called also in French *hydrolats*, are the result of the distillation of plants with ordinary water. They are often a by-product in the manufacture of essences by distillation. The fresh plants are used wherever possible. They are submitted to a maceration of some hours, after which they are distilled by steam or the naked fire. A sufficient quantity of water should be used to cover the materials during the entire operation, and as the essences for the most part are not volatilized completely at 100° (C.), it is often necessary to add salt to the water to raise the boiling point.

The water and the plants are placed in a still and heated gradually, so as not to overheat. If the plants have only a little odor, it is necessary to redistill the product, that is to say, to submit the product to one or more distillations with a new supply of the plants.

The principal distilled waters used in the preparation of liquors are :

1. Waters distilled from the flowers of acacia rose, camomile, lily, lily of the valley, orange flowers, violets, elder flowers, etc.
2. Waters distilled from the flowering tops of balm mint, hyssop, lavender, ground ivy, marjoram, melilot, origanum, parsley, rosemary, sage, thyme, etc.
3. Waters distilled from leaves of the cherry laurel, peach, tea and the odorous leaves of the plants of the labial family.
4. Waters distilled from the fruits of apricots, bananas, cherries, quinces, strawberries, raspberries, peaches, prunes, cacao, coffee, cloves, musk, maize, green nuts, etc.
5. Waters distilled from the rinds of oranges, lemons, bergamot, etc.
6. Waters distilled from the kernels or stones of apricots, bitter almonds, cherries, peaches, prunes, etc.
7. Waters distilled from the grain and seeds of anise, angelica, Chinese anise, cardamom, caraway, coriander, fennel, juniper, parsley, etc.
8. Waters distilled from the bark or skin of the cinnamon, cascarilla, sassafras, etc.
9. Waters distilled from sandal wood, *lignum vitæ*, etc.
10. Waters distilled from calamus, angelica, ginger root, etc.

The general method of preparation is as follows: The flowering tops are cut up ; the fruits pulped, with their seeds or kernels ; the skins or rinds are contused in a mortar ; the roots, seeds, etc., are crushed ; the wood and tough roots are rasped. The materials which have been thus treated are macerated with 2·5 per cent. of salt and four times their weight of cold water for twenty-four hours. After this time the mass is thrown into a still and submitted to distillation.

The following are examples of distilled waters :

Absinthe Water.
Eau Distillée d'Absinthe.

Top leaves and stems of the absinthe .... 1 k.
Salt .... 25 grm.
Water .... 1 l.

Distill so as to obtain 1 l.

In the same manner the balm mint, marjoram, origanum and the rose are distilled.

Acacia Rose Water.
Eau Distillée d'Acacia Rose.

Fresh flowers of the acacia rose .... 1 k.
Salt .... 25 grm.
Water .... 4 l.

Product, 2 l.

In the same manner the following distilled waters are produced: Violet, lily and lily of the valley, fresh flowering tops of the hyssop, lavender, ivy, melilot, balm mint, sage, thyme, etc. Also the following: Orange, bitter almond, apricot, cherries, peaches, prunes, anise, Chinese anise, caraway, fennel, juniper, etc.

Anise Water.
Eau Distillée d'Aneth.

Dry anise seeds	1 k.
Salt	50 grm.
Water	8 l.

Product, 4 l.

In the same manner are prepared the distilled waters of angelica, coriander, parsley, etc.

Coffee Water.
Eau Distillée de Café.

Browned coffee	1 k.
Water	13 l.

Cinnamon Water.

For the bark of cinnamon and for roots and woods in general, take:

Material	1 k.
Salt	400 grm.
Water	16 l.

Distill twice, so as to obtain 8 l.

Water of Lemon Peel.
Eau Distillée de Zestes de Citron.

For distilled water from the skins of lemons, oranges, bergamot, etc., take:

Material	1 k.
Salt	100 grm.
Water	20 l.

Product, 10 l.

Distilled Water from the Pulp of Fruits.
Eau Distillée de Fruits Pulpeux.

Pulp of fruits	1 k.
Water	4 l.

Product, 2 l.

Cherry Laurel Water.
Eau Distillée de Laurier-Cerise.

Leaves of the cherry laurel cut fine	1 k.
Salt	50 grm.
Water	1 l.

Product, 1 l.

In the same manner distilled waters are prepared from the leaves of the apricot, cherry and peach trees.

Distilled Water of Tea.
Eau Distillee de Thé.

Tea	1 k.
Water	20 l.

Product, 10 l.

(To be continued.)

ABSTRACT OF MUNROE'S LECTURES ON CHEMISTRY AND EXPLOSIVES.

By Lieut.-Col. J. P. FARLEY, Ordnance Dept., U. S. A.

DURING the summer of 1888 a very interesting and instructive course of lectures was delivered to the class of that year by Prof. C. E. Munroe, S.B., F.C.S., etc., at the Torpedo Station, Newport, R. I.

The series appears in Torpedo Station print for the same year as a volume of 400 pages, and in view of its limited circulation it is thought that a brief *resume* of the same may prove of interest to the readers of the *Journal*.

An attempt has been made to follow the general sequence of arrangement under the various headings of "chemistry," "combustion," "gunpowder," "chlorates and nitro-substitution compounds," etc., etc., but the form of expression and presentation of facts are materially altered from the original in the condensed shape required.

COMBUSTION.

Combustion, we are informed, is the result of chemical union between atoms of combustible substances and supporters of combustion; heat and light result from the impact of the atoms; mechanical energy is converted into heat, and the potential energy is lowered.

Oxygen and hydrogen in water proportions when ignited are followed by rapid combustion; the mixture itself constitutes detonating gas, which is produced by electrolysis and has been suggested for use for torpedo charges.

Gases and volatile liquids when mixed with air in certain proportions and ignited give rise to explosions.

Finely pulverized solids, such as coal dust, saw dust, starch, flour, and fine zinc dust, mixed in certain proportions with air, undergo rapid chemical change on ignition.

Solids disappear during combustion and the volume of gases generated increases in bulk with the heat developed. Gaseous compounds of carbon (C), hydrogen (H), and sulphur (S), form with oxygen CO_2, H_2O and SO_2. The coefficient of expansion of a gas for 1° C. is $\frac{1}{273}=0{\cdot}003665$, and from this we may determine pressures for a constant volume and varying temperature.

Radiation, conduction and convection reduce the heat of combustion, but the heat evolved during the reaction is compensating. The materials of explosives should be pure, and the mixtures intimate. Oxygen may be supplied either in the free state to the carbon (C) or else combined, as in $KClO_3$. A mixture of charcoal and potassium nitrate is best adapted for use in ordinary guns, and to this sulphur is added in order to lower the point of ignition.

EXPLOSIVES—GUNPOWDER.

Gunpowder, a mixture of KNO_3 75 per cent., C 15 per cent., S 10 per cent., is nervous, sensitive and susceptible to the slightest change of temperature—to mist, sunshine and dew; whereas, many of the explosive compounds are stored for preservation in water, and are but slightly affected by variations of temperature within reasonable limits.

Col. Rains (Confederate service) incorporated gunpowder by steaming the powder and afterward rolling it. The Russian Wiener powder has its moisture eliminated at the melting point of sulphur (240° F.), and although of uniform density, the grain is porous and absorbs moisture.

Fossano or Progressive powder is an agglomeration of powders of two densities, fine and coarse grain.

The composition of cocoa powder is a trade secret, but from analysis it is thought to be made with underburnt "club moss" charcoal. Its ash contains alumina in quantities not found in the ash of woods usually used for gunpowder charcoal.

Dupont's brown powder consists of saltpeter 78 per cent., sulphur 2·8 to 3 per cent., a carbohydrate (such as sugar) 3 to 4 per cent., and baked woods (underburnt) 12 to 12·5 per cent., which latter retain their fibrous structure. This powder gives high initial velocity with a low maximum pressure and possesses advantages over black powders, owing to the form, size, density and hardness of grain, which features, combined with a lesser proportion of sulphur, reduce the readiness of ignition. After the initial movement of the projectile the grains are somewhat broken up, which new condition, added to the greater inflammability of the underburnt charcoal and carbohydrates, promotes chemical reaction and maintains the pressure.

Loss of velocity in gunpowder during storage is thought to be due to action of the oxygen condensed in the pores of the charcoal, which oxidizes the sulphur to SO_2, which by union with the water present is transformed into H_2SO_4, which then decomposes the KNO_3, forming K_2SO_4 and HNO_3. This HNO_3 induces further oxidation, and the cycle of changes proceeds again and again, its rapidity being increased with time. It is this inert K_2SO_4, therefore, which serves to retard the velocity of combustion.

During explosion of gunpowder the following chemical changes take place. The oxygen of the niter converts the charcoal chiefly into CO_2, part of which assumes the gaseous state, while the remainder is converted to K_2CO_3. The greater part of the sulphur is converted into K_2SO_4, and the chief part of the nitrogen contained in the niter is evolved uncombined. Potassium carbonate, potassium sulphate, carbon dioxide and nitrogen result, the last two being gases, which are expanded by the heat of combustion.

CHLORATES AND NITRO-SUBSTITUTION COMPOUNDS.

$NaNO_3$ (sodium nitrate) can be substituted for KNO_3 for blasting and other powders. Ammonium, barium or lead nitrates have been used with considerable success, but the latter gives off poisonous fumes. The chlorates contain less oxygen than the nitrates, but give all of it up during the reaction, whereas with the nitrates some of the oxygen remains attached to the acid radical.

Chlorates are decomposed at 352° (C.), while oxygen is not evolved from the KNO_3 until red heat is reached, and combustion of bodies in contact with chlorates results in developing very high temperature; greater by one-half than that of the nitrate powders; therefore, they possess greater force.

Chlorate powders are sensitive to friction and percussion, explode with sharpness, erode the walls of the gun to a greater extent than the nitrates, and the chlorine gas liberated after firing is deleterious to those who are exposed to its action. The manufacture and handling of the powders is attended with risk and is comparatively costly.

The chlorate powders have been used in fulminating primers and percussion caps. Siemens takes saltpeter, chlorate of potash and a solid hydrocarbon, and, mixing the same, he treats the product with a liquid volatile hydrocarbon as a solvent for the solid hydrocarbon. The mass is plastic, and after passing through rollers is rendered hard by evaporating the solvent. The cakes are then broken up and converted into grains. This powder has the same density, greater hardness, and double the force of ordinary gunpowder.

Mellard's paper powder consists of—

Potassium chlorate	9
" nitrate	4·5
" ferrocyanide	3·25
" chromate	1/16
Charcoal	3·25
Starch	1/21

Porous paper, when dipped into the liquid, is rolled into cartridges, dried and coated with xyloidine.

This powder is cheaper than other chlorate powders, fairly safe and easy to make; it gives off very little smoke, leaves but little residue, is only slightly erosive and is more powerful than gunpowder.

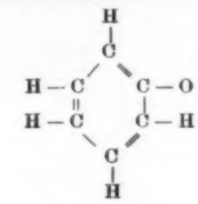
A chlorate powder termed "White powder," being very erosive in its action on iron and steel, its use was restricted principally to bronze guns and shell charges. The shells contain the "White powder" and glass bulbs filled with sulphuric acid, which latter break on impact. This principle of explosion by *admixture* has been applied in the use of certain contact torpedoes; the charge, consisting of black powders, being fired by means of sulphuric acid and "White powder." It has also been applied in pile driving; the explosion not only drives the hammer back, as intended, but also drives the pile forward an additional amount and accelerates the work.

Explosive substances before referred to, such as nitrate and chlorate mixtures, have been produced by mixing combustible matter and oxidizing salts. The next step is the introduction of oxidizing agents into chemical molecules by chemical means, these molecules being composed chiefly of atoms which have a strong affinity for oxygen and form with it under suitable circumstances very stable and permanent substances whereby a great degree of intimacy is obtained. This combination with hydrocarbons may be effected through the agency of the oxides of nitrogen, and it may result in the formation of two classes of compounds, viz., nitro-substitution compounds, in which the nitrogen oxide is directly attached to the carbon atoms, and nitric ethers or *esters*, in which the nitrogen oxide is connected to the carbon atoms, through the interposition of oxygen atoms. The best example of the first class is picric acid, which is made by the action of nitric acid on indigo, or of nitric acid on phenol (carbolic acid). The latter reaction is expressed by the formula:

$$C_6H_5OH + 3HNO_3 = C_6H_2(NO_2)_3OH + 3H_2O.$$

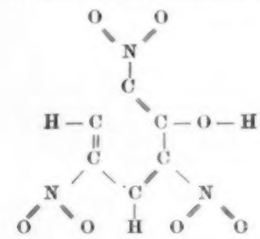
Picric acid was discovered by Hauseman in 1788, resulting from the action of nitric acid on indigo. By Weller, in 1795, nitric acid on silk; but the best and cheapest method and the one used for making commercial picric acid is derived by the action of nitric acid on phenol (carbolic acid).

The reaction is thus expressed:



PHENOL.

Below it is seen that three atoms of hydrogen have been replaced by three atoms of nitrogen oxide.



TRI-NITRO-PHENOL OR PICRIC ACID.

$$C_6H_5OH+3HNO_3=C_6H_2(NO_2)_3OH+3H_2O.$$

Phenol is a product of coal tar, and the picric acid thus produced is an important article of commerce; in fact, one of the cheapest and most brilliant of the yellow dyes.

It can be prepared experimentally by putting two teaspoonfuls of fuming nitric acid in a glass flask of 150 cm. capacity and adding cautiously and in small portions half a teaspoonful of crystallized phenol. The reaction is very violent and is attended by copious development of nitrous fumes. When the action has subsided and the flask becomes cold, yellow crystals of picric acid will be found in the liquid. Picric acid is made commercially by melting carbolic acid, mixing it with strong sulphuric acid and then diluting the sulpho-carbolic (or "phenol sulphuric acid") with water, after which it is run into a tank containing nitric acid. The mixture is allowed to cool and the crude picric acid crystallizes out.

The crystals are again dissolved in water by the aid of steam, cooled and crystallized and a third time dissolved, this time in hot water, then cooled and allowed to crystallize, after which any excess of water is removed by a centrifugal machine. Great differences of opinion exist respecting the explosiveness of picric acid. No one is prepared to say, however, that under no circumstances unconfined picric acid can be exploded by action of fire, but when mixed with metallic nitrates explosion will then surely result. It can when unmixed be exploded by detonation or blow, and when mixed with the metallic nitrates, if detonated, it is highly explosive. In 1873 Sprengel stated that picric acid, without help of foreign oxidizers, is a powerful explosive, even when fired without a detonator, and that such explosion is not accompanied by smoke. Turpin, in 1885, exploded picric acid by employing a powerful fulminate detonator, or by an intermediate priming of picric acid in powder primed with a fulminate; also by employing a large charge of ordinary brown powder inclosed in a strong tube and made to burn *inside* of the picric acid charge.

Picric acid may be perfectly detonated by means of a five grain fulminate detonator.

Detonating a small quantity of picric acid will detonate a quantity of the same acid at a distance from it, and detonating a charge of picric acid placed alongside of another charge of the same acid containing 17 per cent. of water, the former will also cause the detonation of the latter.

When picric acid is near its melting point (240° F.) one pound falling 14" will explode it. When cold and in thin sheets (dry or powdered) one pound falling 26" will explode it.

Berthelot, confirming Desortiaux, states that should a nitro compound (nitro-benzine or naphthalene) such as picric acid, while burning in large masses, by chance, heat the containing inclosure or vessel sufficient to induce incipient deflagration, this deflagration may combine to further increase the temperature of the inclosure, and detonation will result.

The large number of compounds denominated picrates (of which ammonium and potassium picrates are the principal ones) are, with the exception of the ammonium picrate, easily exploded by heat or blows. The ammonium picrate, although containing the most oxygen, requires a large addition of oxygen to insure complete combustion, and is therefore the least sensitive of the picrates; whereas the barium picrate, which, although it contains the least oxygen, requires the least amount of oxygen of all the picrates for combustion, is, in consequence, the most sensitive of the picrates. Potassium picrate, $C_6H_2(NO_2)_3OK$, is one of the most violent of all the picrates in its action. It is made by mixing potassium carbonate, warm, with a solution of picric acid in water. On cooling, the liquid deposits small crystalline needles of a golden yellow color, which show green and red by reflected light. Its explosive qualities increase much by oxidizing agents and especially with potasssium chlorate, and almost equal those of nitroglycerine and gun cotton in violence, but owing to its sensitiveness to friction and percussion it is perfectly useless.

The Designolle cannon powder consists of potassium picrate 16, potassium nitrate 74, and charcoal 9. A

shell charged with this powder will be broken into six times as many fragments as when charged with gunpowder. It does not erode the piece, gives scarcely any fumes, and its ballistic properties are much superior to those of gunpowder—notwithstanding this powder is the more *brisant* of the two.

Spontaneous decomposition is not anticipated, such as sometimes occurs with nitro-glycerine and other nitric esters, owing to the definite composition and known reactions of this, as well as of the whole series of crystalline bodies denominated picrates.

Ammonium picrate, $C_6 H_2 (NO_2)_3 ONH_4$, is prepared by saturating warm picric acid with concentrated ammonia water. After this operation has been repeated with slight modification several times, the liquid is allowed to stand and the salt crystallizes out in transparent orange-colored prisms. It may also be obtained in citron yellow needles by treating picric acid with ammonium carbonate.

Abel's picric powder is composed of ammonium picrate 42·18, potassium nitrate 53·93, charcoal 3·85.

Its force is greater than that of gunpowder in the ratio of 1·75 to 1. It can be moistened, worked, and granulated, as is the case with ordinary gunpowder. Its color is yellow green and it gives off the same colored smoke. This powder, it is said, does not contain a sufficient quantity of saltpeter.

Ammonium picrate and potassium nitrate solutions undergo mutual decomposition when mixed, but it is singular that no such change takes place when they are simply moistened. For this reason the manufacture of this Abel's powder is rendered quite safe.

S. H. Emmens dissolves an excess of commercial picric acid by aid of gentle heat, in fuming nitric acid, the mixture being a refrigerating one. When evaporated, three grades of crystals at different stages are deposited approximating in composition $C_6 H_3 (NO_2)_3 O_3$.

This material, when mixed with metallic salts, is explosive, and in making emmensite this body, which is called "Emmens' acid," is mixed with both picric acid and a nitrate, preferably ammonium nitrate, and the whole fused together and cast in moulds. The result is a solid mass of bright yellow color, bitter taste, nearly inodorous and with porous structure. It is claimed to be insensitive to shock, blow, or fire, but more powerful than nitro-glycerine when detonated, and when used in the granulated form for a projecting charge it produces but little smoke and does not foul the bore of the gun.

Nitro-substitution compounds may be formed from hydrocarbons, such as benzene and naphthalene. When one atom of hydrogen is replaced by NO_2, there results mono-nitro-benzene. This, when mixed with potassium chlorate in the ratio of 21 to 79, gives Rack-a-rock, 204,400 pounds of which were used in blasting Flood Rock. This mixture is made either by pouring the liquid on the solid or by immersing the solid (potassium chlorate) in the liquid, the solid being held in wire baskets. A 24 grain fulminate fuse scarcely suffices to explode this compound when not confined or but slightly confined, which is its chief objection.

In phenol (carbolic acid) the substitution of $3NO_2$ for three atoms of H gives the tri-nitro-phenol or picric acid as before shown. Bellite, discovered by Carl Lamm, of Sweden, consists usually of meta-di-nitro-benzene with ammonium nitrate, which are melted together at 160° F. and mixed with saltpeter. When pressed warm it has a specific gravity of 1·2 to 1·4 and a gravimetric density of 0·8 to 0·875. When heated in an open vessel to 360° F. separation results and evaporation takes place. It burns if heated suddenly, but ceases to burn when the source of heat is removed. It absorbs but very little moisture from the air after it has been pressed.

Under powerful blows it heats, but neither ignites nor explodes; in fact, it may be said to withstand blows, friction and vibration, and can be stored or transported with perfect safety. It is the opinion of those best qualified to judge that it is as well adapted for military purposes as for mining and blasting, and bids fair to become of great importance.

Securite is one of the varieties of bellite, and consists of a nitrated hydrocarbon mixed with an oxidizing agent, such as potassium chlorate, and with some organic salt, which renders it flameless. Its power is said to be equal to dynamite, and it is exploded only by the detonating cap.

Hellhoffite is a solution of a nitrated organic compound (naphthalene, phenol, benzene and the like) in fuming nitric acid. It has the same advantages as bellite, but the disadvantage of being liquid. The fuming nitric acid contained in it requires that it shall be stored in closed vessels. As it is rendered completely inexplosive by being mixed with water, it cannot be employed for work under water.

Gruson's explosive of 1881 appears to be especially adapted to all military purposes, whenever a safe but violent explosive is required. It is a secret compound made by dissolving certain crystals in nitric acid, and is probably similar to Hellhoffite. Its ingredients are transported separately and mixed only for use. It requires twice as powerful a detonator as that which explodes dynamite, and when mixed may be neutralized by adding water, the crystals separating out. These crystals burn like sealing wax, but neither the crystals nor the mixture can be frozen at 0° F. The crystalline ingredients are some well-known substance which is freely transported, but what it is we are not informed; this is Gruson's secret. The ingredient is not soluble in water, does not absorb moisture and therefore never becomes damp. The solid components of Gruson's explosive look like brown sugar, the crystals are needle-like, and nearly an eighth of an inch in length.

They burn in the flame of a Bunsen burner with much smoke. If dissolved in nitric acid a drop of the same when placed on an anvil and hammered will not explode. Paper dipped in the solution serves the purpose of a wick when ignited, and burns with increased flame, but without igniting the solution. Water poured on the solution causes recrystallization, but this change is not attended with material reduction of temperature. The crystals may then be separated from the nitric acid.

In a tube, exploded by a primer three times as strong as that required for dynamite, its force or energy is estimated as 1·3 to 1 of that of nitro-glycerine.

Hellhoff made an explosive from crude coal tar, but found that the treatment of coal tar with strong nitric acid was a very dangerous operation. Acid of 1·33 to 1·45 specific gravity was used and liquid coal tar gradually stirred into it, the surface of the acid at first becoming covered with the coal tar, which gradually settled to the bottom. The substance thus obtained when washed and purified was mixed with oxidizing bodies (alkaline nitrates, chlorate of potash and the strongest nitric acid being used for this purpose).

Two to five parts of concentrated nitric acid or four to six parts of salts were sufficient for one part of the nitro-derivative.

It was found in the course of experiment that either pulverized coal or peat after treatment with nitric and sulphuric acids, when soaked in a solution of chlorate of potash and dried, forms a powerful explosive, and all nitro derivatives from either of the above ingredients are stronger and better when mixed with oxygenated bodies.

The Sprengel class of explosives of 1873 consists of two liquids, or one liquid and one solid, kept separate until needed for use. Among the oxidizing agents were the nitrates and chlorates, which are solid, and nitric acid and nitrogen tetroxide, which are liquid.

FULMINATES.

The class of fulminates include the salts of fulminic acid and other substances, which under normal conditions undergo detonating explosion only.

Nitrogen chloride is one of the most unstable of the class of fulminates, and although sensitive and dangerous, and its local action is marked, due to detonating reaction, yet its explosive force (Sarrau) is but slightly greater than that of gunpowder. It was discovered by Dulong in 1812, and resulted from the action of chlorine on ammonium chloride. Some chemists regard it as NCl_3 (trichloramide), that is ammonia NH_3, in which all the hydrogen has been replaced by chlorine NCl_3.

Berthelot discovered (1788) silver amine, a powerful fulminating compound produced by the action of ammonia upon silver oxide. It may also be produced by precipitating silver nitrate with sodium hydroxide and washing the silver oxide by decantation. This body explodes by the slightest concussion when dry and requires the greatest caution in handling even when moist. It is claimed to have been the detonating agent used in the bomb that killed the Czar.

The "fulminating gold" is formed as a buff precipitate by adding ammonia to a solution of auric chloride, a violent explosive resulting.

Cupricamine is formed by passing a current of dry gaseous ammonia over finely powdered cupric oxide heated to 250° C. Water and nitrogen gas are evolved, and the nitrate is left as a dark green powder, which, when heated to 310° C., explodes freely.

Mercury amine may be made by passing gaseous ammonia over the dry yellow mercury oxide, which is precipitated from mercury salts by an alkali. This may be continued so long as the gas is absorbed, and by heating the resulting black brown mass constantly (at a temperature not exceeding 150° C.), so long as water is given off, an anhydrous brown powder is produced, which detonates powerfully when heated or struck, and which is decomposed by acids with salts of ammonium and mercury.

Fulminating platinum is produced as an insoluble black powder by dissolving ammonium platinic chloride in a solution of sodium hydroxide and adding an excess of acetic acid. It detonates violently when heated to 200° C.

Nitrogen Sulphide.—This body detonates powerfully under percussion, but is less sensitive than diazo-benzene nitrate or mercury fulminate. It deflagrates at 270° C., but more slowly than mercury fulminate. It is made by passing dry ammonia gas through a solution of sulphur dichloride in ten or twelve times the volume of carbon bisulphide.

Howard, an English chemist, discovered mercury fulminate in 1800, and with this substance began our knowledge of what are chemically known as fulminates. The discovery was made while acting on mercury oxide with alcohol and nitric acid. A whitish salt was produced, which crystallized in acicular needles possessing a saline taste, and which, when dried, exploded with extreme violence when a drop of sulphuric acid was poured upon them. This compound gives extremely low velocity as a propellant, but bursts the gun by the violence of its action. In 1863 Nobel employed fulminate of mercury to detonate nitro-glycerine. It is a salt of an organic acid having the probable proportions $C_2 N_2 O_2 H_2$, and which is known as fulminic acid.

This fulminate is now made by taking 10 parts by weight of mercury and dissolving it by gentle heat in 120 parts by weight of nitric acid s. g. 1·4. It is then poured into a glass containing 100 parts of alcohol (95 per cent.), the flask holding six times the volume of the alcohol. At a temperature of 60° F. action begins, the mixture becomes turbid and generally continues so until the reaction is completed. From 11 to 12 parts of mercury fulminate result from every ten parts of mercury. The fulminate will be found as a pasty mass of fine gray crystals of uniform color, and if different colors are exhibited or globules of metallic mercury are seen, it indicates that the operation has not been properly carried out, and the charge is then known to be unfit for service.

Dry fulminate explodes violently when struck or compressed, or when rubbed between hard surfaces; when heated to 186° C.; when touched with strong sulphuric or nitric acid; when in contact with sparks from flint and steel or from the electric spark. If wet with thirty per cent. of water, it is inexplosive except when dry fulminate is detonated in contact with it. Its density is 4·42 and the reaction attending decomposition is thus expressed: $Hg\ C_2 N_2 O_2 = Ho_2 + 2CO + N_2$.

The superiority of the fulminate of mercury over all other fulminates is due to its nearly instantaneous decomposition by simple inflammation, to the absence of dissociation products and finally to its great density. Definite products of combustion form at once before even the matter has time to take a volume notably superior to that of the primitive solid. Hence if exploded in a vessel and in contact with its sides, it will develop an instantaneous pressure, incommensurately greater than its mean pressure, which latter is controlled by the capacity of the receptacle. Mercury fulminate, with an absolute density 4·42, in contact develops a pressure of 48,000 atmospheres, while compressed gun cotton in contact develops a pressure of not more than 24,000 atmospheres, and no other substance in contact will give a pressure at all comparable with that of the fulminate of mercury. This circumstance, joined with that of the absence of dissociation, makes the compound perfectly irresistible.

The composition for percussion caps consists of 100 parts dry fulminate, 30 water, 50 saltpeter and 29 sulphur, the whole being mixed by rubbing with a wooden pestle on a marble slab. It is dried sufficiently to be granulated, is forced into copper caps and when perfectly dried is varnished or covered with tinfoil to protect it from dampness. The caps are finally dried by a gentle heat and packed in boxes.

The detonators employed in the navy consist of a copper case made in two parts. The lower part is a No. 36 metallic cartridge case and is 1 1-8 long and 11-32 inches in diameter. The upper part is a copper tube 5-8 inches long and 12-32 inches in diameter, open at both ends, which has been cut from a No. 38 metallic cartridge case. A 3-16 inch thread is cut on each of these parts, so that the upper part or cap screws nicely into the lower part. The lower part is fitted with fulminate of mercury up to the lowest thread of the screw. The top part is fitted with a plug made of sulphur and glass, through which the detonator legs pass to connect the bridge with the wires leading to the battery. When the fulminate is dry the spaces in the lower case and the cap are fitted with pulverulent dry gun cotton and the parts are screwed together.

The different grades of detonators, known as blasting caps, are known as single, double, triple, quadruple and quintuple force caps. The single contain three grains of fulminate, the others increase by three, and hence the quintuple contains fifteen grains. They usually consist of 75 per cent. of mercury fulminate and 25 per cent. of potassium chlorate, pressed into the caps under high pressure, and a little gum is added to make it more coherent. The presence of chlorates, nitrates, sulphur, etc., give rise to flame and incandescent particles, whereas mercury fulminate *per se* does not produce either.

In silver fulminate the acid hydrogen is replaced by silver instead of mercury. Certain precautions are to be used in its manufacture. Large vessels are employed to prevent boiling over, which latter would permit the salt to dry on the outside of the vessel and lead to accidental explosion. All flame must be kept away, lest the vapors should take fire and explode. The mixture should be stirred with wooden rods and not hard ones of glass or metal. Paper shovels should be used in removing it, and the fulminate must be kept in pasteboard or paper boxes to avoid the friction of glass stoppers. Finally the vessels holding it must be loosely covered to prevent explosion due to pressing the cover of the box to fit it. The silver fulminate is very poisonous; it consists of white opaque shining needles with bitter metallic taste; dissolves in hot water and separates on cooling. It explodes much more violently than mercury fulminate by heat, the electric spark, friction, percussion or by contact with oil of vitriol.

It explodes at 130° C. when dry or when rubbed by hard substances such as glass dust, sand, or even the edge of a card. It may be rubbed to powder in a porcelain mortar either with a cork or by the finger. If well washed and dried by exposure to the sun, it explodes by the slightest touch. It is used very largely for crackers and detonating toys.

Besides those mentioned, a large number of salts of fulminic acid are known, all of which are unstable and explosive.—*Journal of the Military Service Institution.*

CHEMICAL ARTS IN BIBLE TIMES.*

By Dr. H. CARRINGTON BOLTON.

CHEMISTRY, considered as an art, dates it origin from prehistoric times; considered as a science, it is little more than one hundred years old. The attempts of man to improve his surroundings as respects diet, clothing, and domestic economy familiarized him with certain phenomena now recognized as chemical. The necessity of securing weapons for war and for the chase, and the attempts to alleviate disease, stimulated the application of chemistry to metallurgy and medicine. Among the sources of information concerning the very earliest period is the Holy Bible, which contains a surprising number of facts and allusions to chemical arts.

The ancients were acquainted with seven metals, of which six are mentioned by Moses in a single verse (Numbers xxxi. 22): "Only the gold and the silver, the brass [*i. e.*, copper], the iron, the tin, and the lead," are to be purified by fire when captured as spoil from heathen nations.

Tubal-cain, the seventh from Adam, seems to have excelled in metallurgy, and apparently aided his brother's musical taste by his skill. The remarkable passage in Job xxviii. 1, describing the occurrences of ores and their metallurgic treatment, is well known. With this can be compared Ezekiel xxii. 18. Jeremiah, in chap. vi. 28, seems to describe the process of cupellation of gold and silver.

Of the seven metals, gold is the most attractive, and, occurring native, was early known to men. It is named among the attractions of the Garden of Eden (Gen. ii. 12), and was manufactured into ornaments for personal decoration at a very early period. Of its abundance in King Solomon's reign, testimony is striking. (I. Kings x. 21 and II. Chron. i. 15.)

Silver was early used in currency (Isaiah xlvi. 6), and, as the pieces were not stamped, "wicked balances" and "deceitful weights" were unhappily too common. (Micah vi. 11.)

Copper, commonly called brass, is named by Moses as occurring in the Promised Land (Deut. viii. 9), and is compared in value to gold by Ezra (Ezra viii. 25). Its alloys were in common use.

Tin and lead were frequently confounded in early times, the latter being called "soft tin." The use of leaden tablets for inscriptions is graphically described by Job (Job xix. 23). Solder was known to the Israelites (Isaiah xli. 7) for repairing metallic trinkets.

Iron was much used in Bible times. Among the many articles manufactured of iron are "chariots" (Judges iv. 8), "spear heads" (I. Sam. xvii. 7), "axes"

* Abstract of a paper read before the New York Academy of Sciences, 1892.

(II. Sam. xii. 31), "yokes" (Jer. xxviii. 14), "idols" (Dan. v. 4), "thrashing instruments" (Amos i. 3), and "nails" (I. Chron. xxii. 3). The "bedstead of iron" belonging to Og, King of Bashan, was probably a sarcophagus of stone (Deut. iii. 10). The liquid metal mercury is not mentioned in the Bible nor by Herodotus, though known to Dioscorides and to Pliny.

Besides their metallurgical knowledge, the ancients possessed much skill in general chemical technology; they knew well how to prepare fermented drinks, wine (Gen. ix. 20) and vinegar (Ruth ii. 14).

Beer was known to the Egyptians, and is mentioned by Xenophon as a drink of the Germans about 100 A. D.

The apothecary's art reached a high stage of culture in Egypt, of which the famous Papyrus Ebers gives ample testimony.

Cosmetics were used by Hebrew women for frescoing their faces (II. Kings ix. 30), a custom still prevailing in the East. The art of dyeing fabrics in brilliant hues is among the most ancient of the chemical arts (II. Chron. ii. 7). The luxury of the Israelitish women is well described by Isaiah in chapter iii, 18–23.

The ancients were acquainted with alum, salts of iron, and copper and alkaline carbonates, and used them in mordanting. They also knew brilliant pigments whose durability is unsurpassed. Besides these chemical bodies, the ancients used sulphur, borax, sal-ammoniac, and saltpeter; but the word "niter" in the English Bible is not saltpeter; it is a translation of natron, which is carbonate of soda.

Lye is mentioned by Jeremiah (ii. 22), and soap by Malachi (iii, 2).

Gases as such were hardly recognized by the ancients; the Bible, however, contains one peculiar reference to carbonic acid gas. Solomon wrote: "As one that taketh off a garment in cold weather, and as vinegar upon niter, so is he that singeth songs to an heavy heart" (Proverbs xxv. 20). This refers to the effervescence of carbonate of soda when acted upon by the acid of vinegar.

In the apocryphal work of an Alexandrine Jew called the Wisdom of Solomon, a remarkable passage occurs which seems to foreshadow the fundamental laws of chemistry:

"πάντα μετρῳ χαι αριθμῳ χαι σταθμῳ διέταξας" (Chapter xi. 20).

"Thou hast ordered all things in measure and number and weight."

Two centuries succeeding the birth of Christ saw many illustrious men, Pliny, Dioscorides, Plutarch, Ptolemy, Galen; but the succeeding six centuries were unfruitful in scientific research, owing to the intellectual degradation accompanying the anarchy which prevailed in the political world. Chemistry became the "sacred art" or occult science, and was largely devoted to attempts at the artificial manufacture of precious metals, and the futile search for the philosopher's stone.

COLORING MATTERS OF THE VINE AMPELOCHROIC ACIDS.*

By A. GAUTIER.

THE rapidity with which grapes ripen in mid-Europe led the author to suppose that the skin pigment to which the color is due is formed by the oxidation of aldehydic or catecholic substances, originating in the leaves and traveling thence to the fruit. This view was borne out by the effects following the removal of the leaves from grapes about to ripen, or by the partial or complete stoppage of the circulation between the leaves and stem, the grapes in the first case remaining in a state of arrested development, while in the second the leaves changed in color to red or brown, and not the grapes.

The coloring matter of leaves thus reddened (from plants of the Carignan stock) was extracted with tepid water and purified by fractional precipitation with lead acetate, with which it finally formed an olive-green precipitate; this, on decomposition with hydrogen sulphide and purification, yielded a mixture of two colored crystalline acids, α and β-ampelochroic acids. These were separated by means of cold water, in which the latter alone is soluble.

α-Ampelochroic acid, $C_{19}H_{16}O_{10}$, is bibasic and forms a cochineal-colored powder consisting of ruby-red plates or spindles, soluble in boiling water or cold alcohol, but insoluble in ether. Its solutions are feebly acid to litmus. The *zinc* salt is olive green, and turns indigo blue on heating, the *acid zinc* salt is rose colored and soluble; the *lead* salt is dark green, and blackens at 50°; the *acid lead* salt is wine red. Solutions of α-ampelochroic acid are turned greenish brown by alkalies, and oxidize on exposure to the air; they are precipitated by bromine water; they give a greenish-black precipitate with ferric salts, a dark-brown precipitate with mercuric nitrate, a yellowish-gray precipitate with silver nitrate, especially in presence of ammonia, a rose-colored precipitate with gelatine solution, and a chestnut-brown precipitate with cinchonine acetate. The acid therefore belongs to the classes of tannins and polyphenolic substances.

β-Ampelochroic acid, which is stated to have the composition $C_{22}H_{20}O_{13}$, bears a general resemblance to the α-acid. It forms cochineal-colored crystals, and its aqueous solution is feebly acid to litmus and feebly astringent to the taste. It is precipitated by gelatin and by cinchonine acetate; it gives a violet precipitate with tartar emetic, a dark-green precipitate with mercuric nitrate, a yellowish-brown precipitate with copper acetate, and a chestnut-brown precipitate with hot silver nitrate. Potash turns the color of its solution to yellowish green, and ferric chloride gives a dark violet coloration, changing to a brown precipitate.

A third acid of the same general character as the others was obtained from the first fraction or blue precipitate formed in their preparation. The precipitate was suspended in water, decomposed with hydrogen sulphide, partially saturated with baryta water, and the whole evaporated to dryness in a vacuum. The residue was extracted with ether to remove impurities, and the new acid was dissolved out with alcohol.

γ-Ampelochroic acid, $C_{17}H_{12}O_{10}$, crystallizes in reddish-brown octahedra and dissolves readily in water to a red solution, astringent to the taste. With gelatin and tartar emetic, it forms rose-colored precipitates, which dissolve on heating; with mercuric nitrate, it gives a pale, greenish-blue precipitate, a green precipitate with calcium acetate, an olive-green precipitate with basic lead acetate, a dark violet to brown precipitate with ferric salts, and an orange to yellow precipitate with bromine water. Potash changes the color of its solutions to olive green.

* *Compt. Rend.*, 114, 623-629; *Jour. Chem. Soc.*, October, 1892, p. 1242.

THE Northern Steamship Company propose to put on the great lakes six of the finest passenger steamers ever built for the navigation of American waters. They will run between Buffalo and Duluth, 1,100 miles. Work on two of the boats has already been begun at the shipyards of the Globe Iron Works, Cleveland. The vessels will each have twin screws and three smokestacks. They will be equipped with the finest appointments and will cost nearly $600,000 each. They will have the Belleville boilers, so generally used in the French navy, which are over a third lighter than the ordinary steel boiler, and are considered non-explosive. Quadruple expansion engines, capable of developing 6,500 horse power, will be used. The speed of the boats will be twenty miles an hour.

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TABLE OF CONTENTS.